

University of Massachusetts Amherst

ScholarWorks@UMass Amherst

Doctoral Dissertations

Dissertations and Theses

November 2016

Three Essays on Sustainable Development in China: Social, Economic and Environmental Aspects

Ying Chen

Follow this and additional works at: https://scholarworks.umass.edu/dissertations_2



Part of the [Environmental Studies Commons](#), [Growth and Development Commons](#), [Labor Economics Commons](#), and the [Political Economy Commons](#)

Recommended Citation

Chen, Ying, "Three Essays on Sustainable Development in China: Social, Economic and Environmental Aspects" (2016). *Doctoral Dissertations*. 856.

https://scholarworks.umass.edu/dissertations_2/856

This Open Access Dissertation is brought to you for free and open access by the Dissertations and Theses at ScholarWorks@UMass Amherst. It has been accepted for inclusion in Doctoral Dissertations by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact scholarworks@library.umass.edu.

**THREE ESSAYS ON SUSTAINABLE DEVELOPMENT IN CHINA: SOCIAL,
ECONOMIC AND ENVIRONMENTAL ASPECTS**

A Dissertation Presented

by

YING CHEN

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2016

Economics

© Copyright by Ying Chen 2016

All Rights Reserved

**THREE ESSAYS ON SUSTAINABLE DEVELOPMENT IN CHINA: SOCIAL,
ECONOMIC AND ENVIRONMENTAL ASPECTS**

A Dissertation Presented

by

YING CHEN

Approved as to style and content by:

David Kotz, Economics, Co-Chair

Robert Pollin, Economics, Co-Chair

Deepankar Basu, Economics, Member

Sigrid Schmalzer, History, Outside Member

Michael Ash, Department Chair
Economics

DEDICATION

To my grandparents for teaching me right from wrong;

To Zhun for sharing the belief;

To my child Landon for inspiring me to fight for a better future;

And to a new world without inequality and discrimination.

ACKNOWLEDGMENTS

I have received tremendous help in writing this dissertation. David Kotz has been a great mentor and advisor since the very beginning of my graduate school years. His academic rigor, political commitment and honest personality have always been inspiring. Robert Pollin provided invaluable support to my professional development. No matter a small research idea, or a big life-changing event, he was always ready to talk and he only offered his most sincere suggestions. I learned how to communicate with professors effectively and confidently from countless conversations with him. He edited every single page of this dissertation, though I bear full responsibility for any errors and typos.

Deepankar Basu's comments were always insightful. He showed me how to be a better scholar. Sigrid Schmalzer's comments were stimulating. She kept me aware of the important perspectives that were overlooked by economists.

My special thanks to James Heinz, Heidi Garrett-Peltier who read the early draft of this dissertation and offered crucial suggestions. Karen Pfeifer, a professor of Economics herself and the wife of David Kotz, has always treated me like family. She believed in how much I am able to offer as a female in the field of economics.

I would like to extend my gratitude to my colleagues at the Political Economy Research Institute, Jeannette Wicks-Lim, Shouvik Chakraborty, Tomas Herndon for all the pleasant conversations. Also to my fellow EGSOers. the endless meetings are going to be my most cherished memories from the graduate school. Solidarity forever.

Discussions and debates with Zhongjin Li, An Li, Hao Qi, Zhaochang Peng, Li Gu, Zixu Liu, Minqi Li, Srinivas Lankala at the China Study Club and the "blue house" were unforgettable. My thanks to Yajie Sun, my best friend from college, and Qiliang Gan, my late cousin, who initiated my research interests in discrimination. Min Li, our babysitter and later a close friend, contributed to my finishing of this dissertation in time.

Last but not least, I am especially indebted to Zhun Xu, my loving husband for his support in all aspects since we met back in 2007. I am also grateful to my son Landon, whose unexpected arrival to the world shined my life. I deeply appreciate my family members back in China for believing in me and for supporting my career pursuit.

ABSTRACT

THREE ESSAYS ON SUSTAINABLE DEVELOPMENT IN CHINA: SOCIAL, ECONOMIC AND ENVIRONMENTAL ASPECTS

SEPTEMBER 2016

YING CHEN, B.A., SHANGHAI INTERNATIONAL STUDIES UNIVERSITY

M.A., UNIVERSITY OF CHICAGO

Ph.D., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor David Kotz and Professor Robert Pollin

The first essay focuses on the role of the *hukou* (i.e. Household Registration System) with full awareness of the economic system it operates under, and the development model it assists. I find that *hukou*'s main role in the planned economy was to assist socialist industrialization while averting the Lewis development model, a development strategy based on unlimited supply of labors from the rural sector, largely adopted in developing countries. In the market reform period, *hukou* performed exactly the opposite function, which is to assist the Lewis model based on the unlimited supply of rural surplus labor "released" from the rural de-collectivization. Based on these results, I argue that the interacting effects of the *hukou* and the economic system, rather than *hukou* alone, should be the analytical focus to address important development topics such as industrialization, urbanization, spatial and social inequality.

The second essay compares the different agricultural investment patterns when agricultural credit is borrowed on a collective basis versus on an individual basis. I find that on the same income level, a one percent increase in the IC ratio (i.e. the ratio of loan made on individual base relative to on a collective base) leads to of a two percentage point decline on irrigation investment. On the other hand, a one percent increase in the IC ratio leads to about 10 percentage point increase in fertilizer use. Based on these results, I argue that the form of agricultural lending matters significantly in decisions regarding

agricultural investments. Collective-based agricultural lending tends to be channeled to investment that contributes to more sustainable agricultural development yet with returns only in the intermediate or long run (such as irrigation).

The third essay addresses the employment issue through estimating the relative employment impacts of renewable energy investments versus spending within the traditional fossil fuel sectors. I find that spending within three segments of the renewable energy sectors—solar, wind and bioenergy, will produce in combination about twice as many jobs per dollar of expenditure than an equal amount of spending on fossil fuels. I also find that, more than 70% of jobs from renewable energy sectors are created in the informal economy. Overall, the results of my estimates demonstrate that, for the case of China, the project of building a clean energy economy does not face the prospect of a massive obstacle in terms of negative employment effects.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	v
ABSTRACT.....	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiii
CHAPTER	
1. THE HUKOU SYSTEM AND ITS IMPLICATION FOR SUSTAINABLE DEVELOPMENT	1
1.1 Introduction.....	1
1.2 Literature Review.....	4
1.3 Origin of the <i>Hukou</i> System	7
1.4 <i>Hukou</i> 's role in the planned economy	16
1.4.1 Rural-Urban Migration Rate.....	17
1.4.2 Two types of development models	19
1.4.3 Empirical evidence regarding balanced growth model.....	22
1.5 <i>Hukou</i> reform within the market economy	26
1.5.1 Preconditions for the <i>hukou</i> reform	26
1.5.1.1 1982 Agricultural Production System and 1984 Household Responsibility System.....	27
1.5.1.2 1982 Custody and Repatriation policy.....	31
1.5.1.3 1984 Decision on Economic reform and 1986 Labor Contract System ...	34
1.5.2 <i>Hukou</i> 's Reform.....	36
1.5.2.1 Temporary Residence Certificate and the Repeal of UPMG policy	36
1.5.2.2 Implementation of Blue-Stamp Urban <i>Hukou</i>	39
1.5.3 <i>Hukou</i> 's Role in the Market Economy.....	40
1.5.3.1 Creation of Industrial Reserve Army	40
1.5.3.2 Implementing the Lewis Model of Development	42
1.5.3.3 Reinforcing the Urban-Rural Inequality	45
1.6 Conclusion	48

1.7 Bibliography	50
2. DOES THE FORM OF BORROWING AFFECT INVESTMENT PATTERNS? EVIDENCE FROM CHINA 1979-1989	59
2.1 Introduction.....	59
2.2 Background and Literature Review	61
2.2.1 Literature Review.....	61
2.2.2 Historical background.....	67
2.3 Model Specifications and Methodological Concerns	70
2.3.1 Models.....	70
2.3.2 Why use irrigation and fertilizer as the key dependent variables?	73
2.3.3 Supply versus demand effect and the relevant endogeneity issue.....	74
2.4 Data Sources and Descriptive Statistics.....	77
2.4.1 Panel data selection.....	77
2.4.2 Irrigation variable.....	78
2.4.3 Fertilizer variable.....	81
2.4.4 Key regressor: IC ratio.....	81
2.4.5 Other regressors	82
2.4.6 Descriptive Statistics.....	84
2.5 Results and Discussions.....	87
2.5.1 Interpretation of coefficients when the dependent variable contains a fraction value	87
2.5.2 The upper bound limit on the share of effectively irrigated area does not create problems for the estimations	88
2.5.3 Effects of IC ratio on irrigation investment.....	90
2.5.4 Effects of IC ratio on fertilizer investment	91
2.5.5 Marginal effects of Income and Loan.....	92
2.5.6 Alternative measures.....	93
2.5.7 Discussion.....	94
2.6 Conclusion	96
2.7 Bibliography	97
3. RENEWABLE ENERGY INVESTMENT AND EMPLOYMENT IN CHINA.....	116
3.1 Introduction.....	116
3.2 Literature Review.....	122
3.3 Methodology	128
3.3.1 Input-output model.....	128
3.3.2 Methodological concerns.....	130

3.4	Data Construction and Discussion	132
3.4.1	Input-output data	132
3.4.2	Importance of separating the formal and the informal sector employment.....	133
3.4.3	Employment data: formal sector employment.....	136
3.4.4	Employment data: informal sector employment.....	137
3.4.5	Constructing employment-output (E/O) ratios for the informal sector	139
3.4.6	Weighting the renewable energy sector.....	142
3.4.6.1	Selection of three kinds of renewable energy for in this paper.....	142
3.4.6.2	Necessity of country-specific weights	144
3.4.6.3	Solar PV	145
3.4.6.4	Wind.....	146
3.4.6.5	Bioenergy.....	147
3.4.6.6	Combustion.....	148
3.4.6.7	Biogas	149
3.4.6.8	Biofuel.....	150
3.4.6.9	Cost breakdown	152
3.4.7	Traditional fossil fuel sectors.....	153
3.4.7.1	Coal	153
3.4.7.2	Oil/Natural Gas	154
3.5	Results and discussion	155
3.5.1	Employment generation per million of USD	155
3.5.2	Composition of Employment.....	156
3.5.3	Cumulative employment generation.....	157
3.5.4	Output-Investment Ratio (output multipliers)	159
3.5.5	Productivity and declining Employment-Output (E/O) ratio.....	160
3.6	Conclusion	162
3.7	Bibliography	165
	BIBLIOGRAPHY	195

LIST OF TABLES

Table	Page
1.1. Growth Rates of Total Industrial and Agricultural Output, Rural Mechanization, and Net Rural-Urban Migration Rate, 1950-1980	55
2.1. IC Ratio by Province for the 1 st , 6 th , 11 th years.....	104
2.2. Summary Statistics of Key Variables	106
2.3. Sample Statistics by Income and Loan Quintiles	108
2.4. Regression Results for Level of Irrigation and Level of Fertilizer Use.....	109
2.5. Marginal Effects of lagged IC ratio on the level of irrigation	111
2.6. Marginal Effects of IC ratios on the Level of Fertilizer Use	112
2.7. Marginal Effects of lagged IC ratio on the growth rate of effective irrigated area	113
3.1. Employment estimates of investing renewable energy in the existing literature.....	169
3.2. Annual average wage (RMB) comparison between urban unit employees and rural migrant workers.....	171
3.3. Urban employment and urban units employment in 2007 and 2012 (in millions)	172
3.4. In-grid solar PV electricity investment costs in 2006.....	173
3.5. Cost components of Solar PV of roof-top and ground-mounted types.....	174
3.6. Cost Structure for the Chinese Solar PV industry in 2012	175
3.7. Detailed cost structure for the Chinese Solar PV industry in 2012	176
3.8. Industries and Weights for Solar Energy in the I-O Models	177
3.9. On-shore wind energy cost structure: the world average versus China.....	178
3.10. Industries and Weights for Wind Energy in the I-O Models	180
3.11. Bioenergy cost structure	181

3.12. Industries and Weights for Bioenergy in the I-O Models.....	182
3.13. Industries and Weights for Coal in the I-O Models.....	183
3.14. Cost structure of Oil/Natural Gas energy.....	184
3.15. Industries and weights for oil/gas energy in the I-O Models.....	185
3.16. Total employment generation in renewable energy and fossil fuel energy sectors (unit: jobs per \$1 Million).....	186
3.17. Formal and informal employment share in total employment in renewable energy and fossil fuel energy sectors.....	187
3.18. Formal employment generation in renewable energy and fossil fuel energy sectors (unit: jobs per \$1 Million).....	188
3.19. Informal employment generation in renewable energy and fossil fuel energy sectors (unit: jobs per \$1 Million of USD)	189
3.20. Total Employment generation between 2010 to 2015	190
3.21. Cumulative employment generation by 2020, 2030 and 2050 relative to 2010 level.....	191
3.22. Output multipliers and percentage changes in energy sectors in China, 1995-2011	192
3.23. Productivity changes in energy sectors in China	193

LIST OF FIGURES

Figure	Page
1.1 Net Rural-Urban Migration Rate 1950-1990.....	57
1.2 Growth Rate of Rural Mechanization 1952-2008.....	58
2.1. Scatterplot of the Irrigation and IC	114
2.2. Scatterplot of the Fertilizer and IC.....	115
3.1. Typical cost components for renewable power generation technologies by region	194

CHAPTER 1

THE HUKOU SYSTEM AND ITS IMPLICATION FOR SUSTAINABLE DEVELOPMENT

1.1 Introduction

In this paper, I examine the role of the Household Registration System (i.e. *hukou*), in both the planned economy period (1950s to late 1970s) and the market economy (early 1980s to now) period in China. I show that the commonly held view that *hukou* is the reason for urban and rural inequality is not well-grounded in evidence. This view does not differentiate *hukou*'s effects that result within the context of alternative policy settings, i.e. the planned economy versus the market economy. Not differentiating *hukou*'s impacts under different interactions with other policies risks a misjudgment about the effect of the still ongoing *hukou* reform. For example, the official discourse is that the repeal of the *hukou* system will help alleviate urban and rural inequality. My study suggests that the reality is more nuanced when understanding *hukou*'s roles within the context of different economic systems.

The *Hukou* system refers to the household registration system that records the information of Chinese citizens with regard to their names, dates of birth, birth places, addresses, family members, and occupations. It was officially implemented nationwide in 1958. The distinct feature of China's *hukou* system is that different social policies are often associated with regard to the birthplaces and occupations registered in *hukou*. Despite several reforms, the *hukou* system has still been effective in controlling residents' accessibility to resources, and therefore influences the labor mobility across provinces.

For example, compared to residents with local *hukou* (i.e. meaning they were born in a given province), policies are stricter to residents who want to purchase real estate properties in the places they are residing in but without local *hukou* (i.e. meaning that they were not born in this province). There will be limitations on the total number of apartments or houses that can be purchased by the residents without local *hukou*, or the number of years they have resided and paid taxes to the local government before they are qualified to make the purchase, although specific policies vary across different places. Constraints are also imposed on the children of the residents without local *hukou*, with regard to their access to primary education and high-school education services. These policies generate controversies especially when the more economically developed areas have promising real estate values as well as better educational resources. Occupation-wise, residents with agricultural *hukou* (i.e. *nongye hukou*) are entitled to the right to use land for agricultural purposes while those with non-agricultural *hukou* (i.e. *fei nongye hukou*) are not. In 2014, the distinction between agricultural and non-agricultural *hukou* was repealed. Now, like urban residents, rural residents can buy and sell the village land that was once entitled to their original agricultural *hukou* as they wish. This reform facilitates land concentration and the transfer of village land to outside developers and agribusiness companies (Andreas and Zhan 2015).

The *hukou* system is usually considered as an institutional basis for the broader rural-urban chasm (Cheng 1991; Chan, 1994; Knight and Song, 1999; Solinger, 1999; Yu 2002; Alexander & A. Chan 2004; Wang 2005; Whyte, 2010; Qin 2013). This generalization of *hukou*'s function fails to take into account the economic system *hukou* operates under. In this essay, I examine the interacting effects of the *hukou* and different

economic systems based on a review of historical policy documents, data on migration from rural to urban sectors, agricultural output and industrial output growth. I argue that *hukou* has different economic and social effects when operating under different economic systems. Under the planned economy, *hukou*'s main role was to assist socialist industrialization while averting the Lewis development model widely adopted in other developing countries. Under the market economy, *hukou* performed exactly the opposite function: to assist the Lewis development model based on the unlimited supply of rural surplus labor "released" from the rural decollectivization. The Lewis model is a development model that builds on the idea of unlimited supply of surplus labor from the rural sector (or non-capitalist, subsistence sector) to the urban sector (capitalist sector). The unlimited labor supply leads to the low wage and thus (assumed) high investment development path, until the exhaustion of the rural sector surplus labor, or "Lewis turning point". At this point of exhaustion, wages of the urban sector will be forced to increase and the economy is then considered developed.

The essay will be organized as follows. In Section 2, I review the existing studies and show that they have largely missed the discussion about how *hukou* actually functions with the assistance of other policies implemented in different time periods. In Section 3, I examine some historical policy documents to study the origins of the modern *hukou* system. I show that *hukou*'s function of migration control was only made possible after the implementation of the Unified Procurement and Marketing of Grain grain policy. Section 4 uses evidence to show how *hukou* assisted the planned economy to achieve a balanced growth of both industrial and agricultural sectors. Section 5 examines how *hukou* assists a

Lewis development model in the market economy, with the assistance of a series of policies preceding the *hukou* reform. Section 6 concludes the essay.

1.2 Literature Review

The existing studies on *hukou* have not addressed sufficiently the different functions that *hukou* played under the planned economy and market economy. Most scholars focus on the restrictions the system has imposed on rural-urban labor mobility, or the privileges that came with the urban *hukou*. Yet they tend to overlook the discussion about how these restrictions and privileges have implications on the overall economic development models. As a result, they are not able to recognize that some of the social impacts are not the results of *hukou* alone, but result from other policies that are specifically associated with the broader economic system.

A number of studies attribute the *hukou* system as the institutional base for the rural/urban chasm over the past 60 years (Cheng 1991; Chan, 1994; Knight and Song, 1999; Solinger, 1999; Yu 2002; Alexander & A. Chan 2004; Wang 2005; Whyte, 2010; Qin 2013). Some compare it to the South African Apartheid system (Alexander & A. Chan 2004; Qin 2013), because the *hukou* system has divided the population into two “castes.” They are the non-agricultural population that is economically and socially superior to the other “caste”—the agricultural population. These two distinct groups have vastly different opportunities, obligations and socio-economic status (Yu 2002; Chan& Zhang 1999). According to these studies, *hukou*-based discrimination is a kind of “birth-ascribed stratification” (Potter 1983).

This is why studies focus on *hukou*'s role in restricting labor mobility from rural to urban sectors in the planned economy as it reinforces such birth-ascribed differences (Yu 2002; Wang 2004). There are some exceptions though. For example, urban residents maintained ties with the countryside by hosting visiting relatives, and through visits home for the Chinese New Year (Brown 2012). Also, urban sector jobs are occasionally available to rural residents, with opportunities for rural residents to permanently settle down in the urban sector (Wu 1994).

When the restrictions on labor mobility were lifted in the market economy in the early 1980s, scholars shifted their focus to the urban privileges associated with the *hukou* system. Rural migrants now indeed had higher chances to take up jobs in the cities compared with in the planned economy experience, but a full conversion from rural residents to urban citizens remained difficult for ordinary peasants (Cai & Chan 2000). Usually, these chances were only open to the very wealthy who could afford to “purchase” urban *hukou* status, or, “the powerful, educated and talented, and needed manual laborers” (Wang 2004).

Going beyond *hukou*'s impact on ordinary residents, some studies view *hukou* as part of a larger economic and political system set up to serve multiple state interests (Chan & Zhang 1999; Wu and Treiman, 2004; Wang, 2005; Naughton 2007; Fan, 2008). For example, much of the existing literature recognized *hukou*'s important role in contributing to China's development of heavy industry in the socialist era (Cheng 1991; Chan 1992; Lin et.al 1994; Mallee 1996; Cai & Chan 2000; Chan 2009). At the same time, many considered this strategy detrimental to the development of both the urban and rural sectors (Ka & Seldon 1986; Yu 2002). Specifically, Ka & Selden (1986) argued that *hukou*

assisted China's socialist industrialization through restricting rural-urban labor mobility, and therefore depressing income and consumption levels so as to help transfer agricultural surplus to strategic industries. They further argued that this development strategy is no more pro-rural than the urban-biased capitalist industrialization in Taiwan because of the intentional repression on income and consumption in the rural sector (p1296). Yu (2002) argued that both sectors were worse off during the socialist era because the productivity of the urban sector workers was hampered due to the lack of competition from the rural surplus labor.

The early studies rarely engage the discussion of *hukou* policy with urbanization issues. However, this topic was picked up recently by Chinese scholars in the context of debates regarding rural land privatization. Chan (1992) highlighted the deliberate under-urbanization rate relative to the high industrialization speed in the planned economy period and suggested that the reverse, over-urbanization, is happening in the market economy period.¹ This over-urbanization issue is especially severe when the public infrastructure (i.e. transportation) proved to be insufficient to meet the demand by surging migrant workers who need to travel back to the rural sector for the Chinese New Year. Regarding these migration issues, Chan (2001, 2009) argued that the root cause was *hukou*'s restrictions on the permanent stay of rural residents in the urban sector. He thus proposed that the permanent settle-down of rural-urban migrants will be possible as long as the *hukou* restriction is lifted, and these migrants are also guaranteed access to education facilities and housings in the urban sector. Others disagree with the argument, suggesting that the

¹ According to Chan (1992), This unique "anti-urban" policies including "a tight control of rural-urban labor and population mobility, fuller utilization of the existing urban working-age population, suppression of the expansion of urban service employment and personal consumption in general, promotion of rural industrialization and increased use of urban 'temporary' workers".

ownership of land is the key reason why there is no massive permanent migration from rural to urban area (Wen 2007, Qin 2013).

The problems with these analyses are that these economic and social impacts that were attributed to *hukou* were actually the results of the interaction between *hukou* and other policies. To incorrectly identify *hukou* as the only cause for these impacts is running the risk of false evaluation of the effect of repealing the *hukou* system as is discussed in the context of urbanization debate. This confusion of *hukou*'s function is partly why the existing literature has been ambivalent towards the future of the *hukou* system. Some argue that *hukou* is playing a critical role in China's current export-oriented development model. The repeal of the system will deteriorate the welfare services accessible to urban citizens and cause social tensions (Huang 2001; Yu 2002; Li 2012); Others think an urgent reform of *hukou* is needed, if China wants to push for further economic reform and to become "a modern, first-world nation and global leader" (Chan 2009; Qin 2013; Zhang 2013).

Overall, despite many insights on *hukou*'s role in both the planned economy and market economy periods in China, the existing studies fail to separate *hukou*'s social impacts from those caused by the changes in the economic systems. For the few studies that paid attention to such structural change, the evidence on which they relied is not updated. This essay focuses on the function of the *hukou* with full awareness of the economic system it operates under and the development model it assists.

1.3 Origin of the *Hukou* System

Hukou is associated with three levels of functions. They are the functions of 1) civilian registration; 2) migration control; and 3) employment regulation. Each function

needs the other two function(s) as its basis. By reviewing several policies preceding the official implementation of hukou system in 1958, I argue that *hukou*'s function goes beyond civilian registration and migration control as the existing studies often claim. Its main function was to assist with the urban full employment goal through regulating internal migration according to economic planning. Moreover, the alleged migration control function of *hukou* was actually achieved through the overlooked Unified Procurement and Marketing of Grain (UPMG) policy adopted in 1953. *Hukou* only played a secondary role to the UPMG policy regarding regulating migration.

The existing studies trace Hukou system back to the *baojia* system in the Song dynasty of the 11th century (Cheng & Selden 1994). The *baojia* system was a military management structure imposed on civilians for security reasons. The basic structure is as follows: Ten households made up one *pai* (row), ten *pai* constituted one *jia* (tithing), and every ten *jia* formed a *bao* (watch). If there is crime committed by one family in a *pai*, it would result in punishment for all ten families in that *pai*. This management structure had been revised over time, and was continuously revived under the Chiang Kaishek government in 1912 and under the Japanese occupation in 1933, in order to monitor and control Chinese civilians.

Such association of the *hukou* system with the *baojia* system suggests a focus on the civilian registration function of *hukou* as its basic function. Indeed, policies for civilian registration, migration and employment were initially separate in the history of the People's Republic of China. But then as early as in year 1953, these policies for different purposes started to become interacted. The result, though, was not very satisfactory.

The policy for civilian registration was implemented first. In 1951, the Ministry of Public Security, with State Council Approval, issued a Temporary Regulation Governing the Urban Population.² The main idea of the regulation was to launch a registration system for the urban population only. Urban households were divided into six categories including residential households, industrial and commercial households, public residents (i.e. those living in hotels, inns etc.), floating household (i.e. those living in boats and ships), temple households, and aliens (i.e. residents of foreign countries of origin). Those who intended to move out of the cities had to report to the local public security and apply for a change-of-residence permit. Then they are required to submit this permit to the new residence within three days of arrival.³ Meanwhile, their census record regarding the former residence would be canceled. Under this household registration system, urban residents enjoyed free mobility to a great extent, according to Cheng & Selden (1994, 649). As a matter of fact, anyone who intended to apply for a permit to move out of the original residence could obtain it and then register anywhere, including in Beijing and Shanghai.

Then came the employment policies. In 1952, three years after the establishment of People's Republic of China, the State Council announced a "Decision on Labor Employment Problems" to address urban unemployment and the "blind" influx from the rural sector into the cities.⁴

² Temporary Regulation Governing the Urban Population, or *Chengshi hukou guanli zanxing tiaoli*, issued on 16 July, 1951; published online at <http://www.rmlt.com.cn/2014/0731/300526.shtml>, and retrieved on Jan 16th, 2016.

³ See Article 5 of the Temporary Regulation Governing the Urban Population.

⁴ On 6 August 1952, the State Council issued "Decision on Labor Employment Problems", or *Guanyu jiuye wenti de jue ding*. See Chinese version of the Decision, online at <http://www.chinalawedu.com/news/1200/23051/23052/23055/2006/3/zh97916371113600240-0.htm>, retrieved on Jan 16th, 2016

For the urban sector, the goal was to achieve full employment. Urban unemployment has always been a challenge to the Chinese Communist government since it took power in 1949 from the Kuomintang government. The Chinese government recognized that, in the war recovery period, unemployment is inevitable but only temporary.⁵ Such inevitability is due to the fact that a significant number of people whose expertise and skills acquired in the previous economic system (i.e. capitalist system) cannot find appropriate positions in the current socialist system. These people include, for example, those who previously work for unproductive industries (i.e., luxury consumption and entertainment industries for landlords and former elite class); some intellectuals and former Kuomintang cadres without special skills to join work; and women who previously were not allowed to work outside home but now wanted to work. All these situations contributed to a massive unemployed population with the urban unemployment rate as high as 23.6% in 1949.⁶

The Chinese government's strategy to full employment was to provide training to unskilled workers so that they can adjust to structural changes in the industries. The government also required that enterprises could not lay off workers at will. For example, Article 1 of the document stated that during the industrial restructuring period, those who were temporarily unemployed should not only be paid as employed but also receive training so that they will be prepared for new positions in the upgraded industries. Article 1 suggested that, in principle, labor should follow capital when capital needs to transfer to other industries. However, any lay-offs would require going through various legal

⁵ Ibid.

⁶ Report on the 60 Years of People's Republic of China: the Development of multi-way Employment Structure (*Xinzhongguo 60 zhounian xilie baogao: duofangshi jiuye geju xingcheng*), at http://www.gov.cn/gzdt/2009-09/14/content_1416987.htm, retrieved on July 12, 2016.

processes including application to unions and the Labor Department before the enterprise can legally lay off the worker. As was highlighted in the document itself, the nature of unemployment is different in the socialist system versus in the capitalist system. This strategy to reduce unemployment and the ultimate goal for full employment are indeed distinguished from the political necessity of maintaining a pool of reserve army under the capitalist economy.⁷

This strategy worked successfully. In the beginning of the 1952 document, the Chinese government proudly announced the achievement it had made in dealing with massive unemployment as a left-over problem from China's colonialism period and the Kuomintang period. Specifically, 1.2 million unemployed workers went back to work by December 1951, including 0.6 million in the state mining industry. Another 1 million previously unemployed intellectuals began new employment opportunities after some training offered by the state.

A different strategy was used to solve rural unemployment because of its different nature compared with urban unemployment. For the rural sector, the solution for surplus labor was to cultivate wasteland so that more arable land is made available for rural residents to cultivate. The 1952 document provided the reasoning behind the different strategies in both sectors. The crucial difference between urban and rural surplus labor was that urban surplus labor depended on the rural sector to provide food, while the rural surplus labors "have land to cultivate and have food to eat."⁸ The key contradiction between the surging demand for food production and the existence of rural surplus labor lies in the

⁷ Michael Kalecki 1942, Political Aspects of Full Employment, retrieved online at <http://mrzine.monthlyreview.org/2010/kalecki220510.html>, on Jan 16th, 2016.

⁸ Article 4 of the 1952 Decision on Labor Employment Problems.

problem of “insufficient amount of arable land”, and therefore the surplus labor force in the rural sector should be directed for more food production in the previously uncultivated land. Based on this analysis, the state encouraged that the rural surplus labor pool cultivate the previously wasteland through irrigation building and other cultivation technologies. They were also encouraged to migrate to North-East, North-West and South-West to reclaim the wasteland while not “damaging the water and land condition, and without disturbing the development of animal husbandry”.⁹

Clearly, this grand plan for mobilizing rural surplus labor requires a strong control of labor mobility both within sectors and across rural and urban sectors, as well as a carefully-designed long-run plan. Yet, its enforcement was completely based on persuasion. So is the other Directive issued in 1953.¹⁰ The outcome is quite satisfactory (see Table 1.1). In 1953, the net rural-urban migration rate is 2.7%, dropping almost half from the previous year’s migration rate of 4.6%.

Yet a 2.7% migration rate still leads to a sizable migration population. To strengthen the previous policies that relied on persuasion only, Shanghai and other major cities started to issue a more detailed Household Registration Book (*huji bu*) for civilian registration. The Household Registration Books required the recording of birth, death, residence, education and occupation of every household member, very much like the categories of information required by the later *hukou* system.

⁹ Ibid.

¹⁰ On 17 April 1953, the State Council promulgated a “Directive on Dissuading Peasants from Blind Influx into Cities”, or *Quanzhi nongmin mangmu liuru chengshi de zhishi*. The directive, using persuasive language, urged the hundreds of thousands of peasants who had entered the cities in search of work to return to their villages, exempting those who had already obtained employment and had government or factory papers to prove it.

But it was really after the implementation of the “Unified Procurement and Marketing of Grain” policy (UPMG) that migration control finally became effective.¹¹ In 1953, the UPMG policy, or *Tonggou Tongxiao* policy was initiated to prevent grain speculation and to stabilize the grain price. According to this policy, the state purchased specified amounts of grain from the rural sector and rationed the food to urban residents based on their recorded information on the household registration books. By diminishing the possibility for speculative activities on grains, the goal of grain price stabilization was effectively achieved very soon (Cheng and Selden 1994). At the same time, the UPMG policy also made rural-urban mobility more difficult. This is because as food is strictly rationed to every citizen according to their registration record, rural people can no longer purchase food in urban areas as much as they want. Rural people could still stay in the urban sector temporarily either with food which they had brought to the cities, provided by urban relatives, or they could exchange some grain for grain tickets usable in the city. Yet the stay would not last long.¹²

Although migration control was often associated with *hukou*, the UPMG policy was the *de facto* policy that made migration control possible through food rationing. When migration control became effective, policies for employment regulation started to be effectively implemented as well. As a matter of fact, policies for civilian control and employment regulation started to be explicitly combined.

In 1954, a “recruitment quota” mechanism was introduced so that the urban labor department could use it to hire rural workers based on economic planning (Cheng & Selden,

¹¹ On 19 November 1953, State Council passed “Regulation on Planned Procurement and Planned Supply of Grain”. See Chinese version at http://news.xinhuanet.com/ziliao/2004-12/22/content_2367996.htm

¹² Peasants may use grain to exchange for traveling-place local grain tickets or Grain ticket for nation-wide use according to Article 13 in *Tonggou Tongxiao* Policy, but it would only be a temporary solution for those who are not recorded as residing in urban areas in the household registration books.

1994). These transitions of jobs required a transfer from an agricultural to non-agricultural *hukou*. According to the state plan, the urban labor department made the recruitment decision. Yet instead of directly recruiting rural workers, the urban units need to notify the relevant county and township governments, who would then allocate recruitment quotas to villages for local cadres to make the selection of rural workers. This policy was implemented during the process of massive nationalization and collectivization of agriculture, industry, handicrafts and commerce. Some studies use the analogy of the conversion process with permanent residence in the US immigration system to show how difficult it was for a Chinese rural resident to convert from an agricultural *hukou* to a non-agricultural *hukou* in the planned economy, when immigrants should both fill the requirement and do not exceed the quota of a particular year (Chan 2004). The use of the term “recruitment quota” suggests an embrace of rural-urban migration control as part of the employment regulation under the planned economy.

In 1955, the registration requirement was extended to the rural sector as well. The State Council passed “The Directive Concerning Establishment of a Permanent System of Household Registration”. This required the recording of birth, death, internal migration and immigration information for cities, towns and villages. This Directive could be considered as the antecedent of the 1958 *Hukou* system.¹³

Two months later, the State Council passed “Provisional Measures Governing Grain-rationing in Cities and Towns,” which formally established the food rationing system in detail. For example, Article 4 differentiated seven categories of grain cards

¹³ On 22 June 1955, State Council passed “The Directive Concerning Establishment of a Permanent System of Household Registration”, or *Guanyu Jianli Jingchang Hukou Dengji Zhidu de Zhishi*. This document can be accessed at http://knews.shaanxi.gov.cn/zxfw/www1.shaanxi.gov.cn/bszn/xxxx_p.asp-no1=737.htm, retrieved on Jan 17th, 2016.

regarding residence, occupation and grade, as well as three grain tickets based on the range of its applicability.¹⁴ All citizens needed to bring their Household Registration Book to the local government to receive grain tickets and cards. By this point, the migration control of UPMG policy had been strengthened, and the association of migration control with household registration had become clearer. At the same time, the state managed to largely eliminate private home ownership from 1953 to 1956. Migrants could not obtain housing in the urban sector without obtaining official approval. Even hotels or inns required travel documents issued by work units or local governments (Cheng and Selden 1994, 657). Therefore, another barrier was imposed for any unsolicited migration in terms of housing by 1956.

In 1958, the *hukou* system was officially launched.¹⁵ Every household in cities and towns was required to have a Household Registration Book issued by a local public security organ. In rural areas, Household Registration Book was issued at the unit of collectives. Compared with all of its previous versions that had been advanced for almost a decade, the 1958 Regulations was more specific and stricter, and set up instructions for the registration process. For example, for rural to urban migration, one has to obtain a “move-in permit” first issued by an urban department (i.e. either the urban labor department or urban school enrollment certificate, etc), in order to apply for a “move-out permit” from one’s original

¹⁴ On 5 August 1955, State Council passed “Provisional Measures Governing Grain-rationing in Cities and Towns”, or *Shizheng Liangshi Dingliang Gongying Zaxing Banfa*. The seven kinds of grain cards include city and town resident grain-supply card; Industrial and commercial trade grain-supply card; City and town animal feed-supply card and City and town resident grain-transfer card. The three tickets include Grain ticket for nation-wide use; Local area grain ticket and Local area animal-feed ticket. The document can be accessed at: http://news.xinhuanet.com/ziliao/2004-12/28/content_2388644.htm, retrieved on Jan 17th, 2016.

¹⁵ 1958 Jan 9, the Standing Committee of the NPC promulgated “Regulations on Household Registration in the PRC”, or *Zhonghua Renmin Gongheguo Hukou Dengji Tiaoli*. The Chinese version of this document can be accessed at: <http://www.jincaoj.com/fa/04/law04.55.htm>, retrieved on Jan 17th, 2016.

residential place.¹⁶ This policy suggests that only those who were admitted either to work or study in the urban sector were allowed to migrate.

By now, *hukou*'s three levels of functions including civilian control, migration control, and employment regulation were realized one by one through a series of policies starting as early as 1955. The civilian control function of *hukou* was not new and could be traced back to as early as the 11th century. Yet the effective migration control and employment regulations were the key distinction of the *hukou* system since its official implementation in 1958. This distinctive feature of the *hukou* system was established within the broader economic planning system under which it was operating. These latter two functions cannot be achieved without the assistance of other policies that are also contributing to organizing production and distribution in the planned economy, especially the food rationing policy UMPG.

1.4 *Hukou*'s role in the planned economy

Once the *hukou* system was established in 1958, its three functions (i.e. civilian registration, migration control and employment regulation) started to take effect. Contrary to a common misunderstanding, *hukou*'s priority during the planned economy period was not migration control but to assist the socialist industrialization process. In fact, rural-urban migration reached its peak several months after the official implementation of the *hukou* system in 1958. This is to say that whenever the urban industrial sector needed more workers, *hukou* policy adjusted accordingly to meet industrial needs. In this section I present both the theoretical argument and empirical

¹⁶ See Article 10 of the "Regulations on Household Registration in the PRC".

evidence to show how *hukou* assists socialist industrialization through maintaining balanced growth in both the industrial and agricultural sectors.

1.4.1 Rural-Urban Migration Rate

Hukou's migration regulation function played only a secondary role relative to its purpose in supporting industrialization. Figure 1.1 shows the net rural-urban migration rate from 1949 to 1990 based on the "residual method" developed in Wu (1994). The net rural-urban migration rate was calculated as a "residual" by subtracting the annual natural increase (n) from the annual total increase (g) in urban population. The assumption here is that the rate of increase in the urban population beyond the natural rate of increase birth population in the urban population is due to migration rural to urban areas.¹⁷

As we can see, the greatest rise in migration during the planned economy period occurred in 1958 and 1962 respectively. The year 1958 witnessed the largest rural to urban migration with the net rural-urban migration rate as high as 22.1%. The year 1962 experienced the largest urban to rural migration with the net migration rate as -10.1%. The massive rural to urban migration in 1958 corresponded with the Great Leap Forward, while the massive urban to rural migration in 1962 corresponded with the youth rustication campaign, in which young people were sent to the countryside to learn from the peasants.

¹⁷ Note that this methodology uses the Urban Non-Agricultural Population instead of the Official Total Urban Population in the Statistical Yearbook due to the several revisions that the official statistical definition of urban population has gone through. These revisions have rendered the concept of "urban citizens" more and more loosely defined. For example, a 1982 revision defined urban population as including "all persons who had lived for one year or more, and those who had resided less than one year but had been absent from their place of *hukou* registration for one year or more, within the official boundary of a city/town" (Wu 1994, 678). This revision led to a sudden increase of 60 million of urban population in 1982 from 1981, while a consistent measure suggests only 4 million increase in urban population. See more detailed methodological discussion in Wu (1994), pp 682-84.

The peak of rural to urban migration (22.1%) occurred in 1958, which was exactly the year when the Chinese government officially launched the *hukou* system nationwide. The regulation was announced in January of 1958 together with the full implementation of the *Tongue Tongxiao* policy that imposes food rationing on the urban sector. Therefore, theoretically speaking, we should expect to see rural-urban migration as being moderate starting with 1958. However, in autumn 1958, 38 million people were reported to be mobilized to leave their villages to join iron and steel production projects in the cities, in response to the explosion of urban industrial and construction jobs (Cheng and Selden 1994). Just within three years (1958-1960), the urban population as a share of the national population rose from 15 to 20 percent (Ibid, 664). Obviously, the *hukou* system that was established in that year was not being strictly enforced. As the General Manager of the Huhhot Iron and Steel Mill said, this was a year of “jobs scrambling for people. As long as you could read and write and had good health, you qualified for employment in any factory. *Mangliu* (Blind Influx) were also welcome. No migration certificate was required” (Cheng and Seldon 1995).

Clearly, the top priority of state at this time was not to control migration from the rural sector to the urban sector, but socialist industrialization in the urban sector. When things get in the way, even the newly established *hukou* system could become just a formality. *Hukou*, as a tool under the planned economy was adjusted and loosened so as to encourage, rather than restrict, migration based on the needs of production. However, this wave of uncontrolled migration left an insufficient supply of workers to cultivate the land. This is one of the key factors that contribute to the notorious Great Famine. The detrimental effect from uncontrolled migration further proved the importance of migration control

especially under the specific context in China. That context was the economy with agriculture still being labor-intensive and with urban sector solely dependent on the agricultural sector for food provision.

1.4.2 Two types of development models

The key feature of the development model in the planned economy is its aim to achieve a balanced growth between the industrial and agricultural sectors. The growth is balanced in the sense that the industrial sector development does not come at the cost of squeezing agricultural development. Socialist industrialization was the goal of New China. To achieve that goal, the industrial sector needed food subsistence produced by the agricultural sector. It also needed rural workers to join the urban working class but not too many to threaten sufficient production of food to feed the entire population. The industrial sector also needed the rural population to consume their industrial production. In order for the rural sector to play these three roles (i.e., food provision, labor supply and industrial goods consumption), a population balance must be maintained between the urban and rural sectors for a long-run sustainable development trajectory.

From a static point of view, *hukou* under the planned economy did prevent peasants from entering the urban areas at will. But in a dynamic view, a planned and control migration for now would be necessary for a massive migration in the future. How can more peasants join the urban labor forces without affecting agricultural output levels? A prerequisite is a massive mechanization of the agricultural sector so that rural laborers can be “freed” to support industrial production in the urban sector. At the same time, the

mechanization of the rural sector needs the assistance from the industrial sector. Therefore, again, a balanced population between the two sectors is necessary to guarantee good performances of both sectors.

A typical development model is one that concentrates on industrialization by attracting labor from the rural sector. The natural outcome of such a development strategy is that the stronger, and the more educated people chose to move to the urban sector, leaving the agricultural sector diminished. This development strategy is strongly unbalanced between the urban and the rural sectors. It has been used in many other developing countries, and is succinctly summarized in the Lewis model.

According to Lewis, due to an overpopulated rural sector relative to the available natural resources (i.e. arable land), the marginal productivity of rural labor is zero or even negative. Meanwhile, the urban sector exhibits relatively higher productivity, thus offering relatively higher wages, and that would attract an “unlimited supply” of rural surplus labor at this subsistence wage. As more and more rural laborers leave the village to the urban sector, those who are staying in village will have a larger share of food supply at a given output level. This is supposed to be a positive outcome for the rural residents. Meanwhile, capitalists (i.e. employers in the urban sector) started to accumulate profits by paying workers only the subsistence wage at the initial stage of capitalist development. The profit they earned translates into investment which drives the economy. This accumulation period ends when the unlimited supply of labor (from the rural sector and foreign immigration) is exhausted and capitalists have to start paying wages higher than the subsistence level. When the overall wage level in the urban sector is lifted up, the country is considered developed.

However, the Lewis model overlooked an alternative solution to rural surplus labor in the rural sector. That is to cultivate more arable land. Studies show that during the collective years, labor mobilization was high for building productive infrastructure (i.e. irrigation works, land reclamation, afforestation) and thus rural surplus workers are rare (Patnaik and Natrajan 2000). With the assumption that the only way to solve rural surplus labor problem was to move to the urban sector to look for jobs, the outcome with the Lewis development strategy is a squeezed and diminished rural sector.

A diminishing agricultural sector has problems in the Chinese context. First, population density in China is very high. On average, for every square kilometer of land area in China, there are 145 inhabitants as of today. For the urban sector, this number could go even higher, such as 1525 for Beijing and 3826 for Shanghai.¹⁸ This number is very high compared with only 35 for the United States for example and 49 for the world average. An unattractive agricultural sector will lead to an even higher population density in the urban sector, posing problems for accessing resources such as health care, housing, and education (Zhang and Kanbur 2005). Second, without advanced technology, the agriculture sector is completely dependent on physical labor. This way a shortage of rural labors will lead to a drop in agricultural production and pose severe food security issues such as the Great Famine.

¹⁸ Average population density data for China and United States is from World Bank. Urban sector data is extracted from the Statistics Portal for year 2014, at <http://www.statista.com/statistics/279040/population-density-in-urban-areas-of-china-by-region/>. World average population density is from United States Census Bureau at <http://www.census.gov/popclock/>.

1.4.3 Empirical evidence regarding balanced growth model

The key feature of a socialist industrialization in China is that the agricultural sector is not being sacrificed in order for the development in the urban sector. The mechanism to achieve a relatively balanced growth of both the industrial and agricultural sector is as follows: To generate surplus labor from the rural sector without actually harming the agricultural production, there must be a massive rural mechanization and infrastructure building that significantly raise agricultural productivity. This rise in agricultural productivity allows labors to be freed from agricultural-related work while guaranteeing sufficient agricultural production to feed both urban and rural population. When these surplus rural laborers transition to the industrial sector to work, we expect a high growth rate occurring in the industrial sector, which would in turn assist further mechanization of the rural sector.

Table 1.1 shows the growth rates of total industrial output, total agricultural output, and total power of rural machinery extracted from China Statistics Yearbook 2012, with references to the net rural-migration rate calculated by Wu (1994).¹⁹ The data cover the years 1950 to 1980. The second column shows the growth rate of total industrial output. The third column shows the growth rate of total agricultural output. Both growth rates are calculated based on information on industrial output and agricultural output measured in value (RMB). The fourth and fifth columns present data on the growth rate of rural mechanization, where the rural mechanization was measured by the total power of agricultural machinery (kilowatt). Note that the fourth column presents the growth rates based on the original data available. For example, the growth rate of 559.8% for year 1957

¹⁹ The methodology is explained in details in Section 4.1.

suggests that the rural mechanization in 1957 is a roughly 6-fold increase compared to year 1952, the previous year in which data on the total power of agricultural machinery was available. The fifth column presents the compound annual growth rate based on information in the left sub-column. The last column shows the net rural-urban migration rate as discussed in Section 4.1.

As we can see, the first major rural-urban migration occurred in 1958 (with 22.1% rural-urban migration rate), after more than 5-fold increases in total power of agricultural machinery in 1957 relative to year 1952. As one of the achievements of the First Five Year Plan (1953-1957), the significant improvement in agricultural machinery provides the basis for rural mechanization which contributed to the release of rural laborers from the agricultural sector. Such release of rural laborers sets a foundation for the historically massive migration out of the rural and into urban sector in the following year. In this sense, the Great Leap Forward is by no means some random thoughts of some particular policy makers according to the social discourse as of today, but has its objective and material base.²⁰

The year 1959 and 1960 witnessed a significant decline in agricultural growth (-13.9% and -11.2%), corresponding to a lower level (but still positive) net migration rate (1.9% and 4.1%). From these data, we see that the massive influx of rural labor for the sake of Great Leap Forward mainly occurred in the year of 1958 on the basis of significant improvement in agricultural machinery. However, the goal of industry growth was set higher and higher and eventually went beyond what the real agricultural basis could support

²⁰ The same year also witnessed the highest industrial growth rate of 52.95%. Although this statistic could be overstated, we could infer that the industrialization process went smooth and shows very optimistic prospect.

in terms of both labor availability and crop production. Then the natural disaster came as the last straw to the agricultural sector. The first significant decline in agricultural sector in 1959 corresponds with 30% industrial growth. This positive but relatively moderate growth rate can be interpreted as the interaction between both a lagged but positive effect from 1958's fast growth (53%), and a negative impact on industrial sector due to the shock in the agricultural sector (-13.9%). The sudden drop in net migration (from 22.1% in 1958 to 1.86% in 1959), suggests that rural workers stopped migrating to the urban sector, and that many temporary migrant urban workers went back to their previous residence in 1958. The same pattern is also shown by the 1960 data, with industrial growth becoming even slower but still positive (5.5%) and a continuing decline in agriculture (-11.2%). This pattern suggests that under the planned economy, industrial growth depends on agricultural growth, in terms of both subsistence and labor provision.

From 1961 to 1964, the migration rate was persistently negative (with the highest level of -10.1% in 1962), corresponding to the strict implementation of the *hukou* policy in 1960-1962 and a rural exile of 20 million workers discussed above (Cheng and Selden 1995). With more rural labor force returning to work on the farm, the agricultural sector started to recover in 1961 (29.5%) and continued the steady growth until the 1975. The industrial sector took two more years (1963) to recover (12.4%) from the previous two years of negative growth. The two years lag in the industrial sector again justified the importance of agricultural accumulation in the socialist industrialization.

The relatively stable and high level of agricultural growth from 9.8% in 1963 to 16.5% in 1965 corresponds with the industrial growth rate averaging around 20% from 1963 to 1966. The corresponding migration rate is relatively stable but very moderate from

1963 to 1967 (within a positive and negative 3% range). This is partly due to the strict control of migration implemented through the *hukou* system, and also partly because the increasing productivity in the urban sector. As such, the labor requirement for the same level of output is lower compared with previous years.

The start of Cultural Revolution in 1967 corresponded with a relatively lower but still positive agricultural growth (with an average agricultural output growth rate of 3.7%) rate until 1975. Echoing Mao's call for "Reeducation of the Intellectual Youth", institutionalized the youth rustication is reflected by the negative net migration in the years of 1968-1970. The migration rate then turned positive and remained so after, suggesting that the youth rustication program was not sustained at a rapid rate. The industrial sector was affected in the year 1967 (-15.99%) and 1968 (-10.02%), but as the youth were rusticated and the urban unemployment pressure was relieved, industrial sector's growth rate remained positive (with highest level 32.26% in 1970) until 1975.

The rural-urban net migration rate started to surge after the Cultural Revolution, rising to 6.1% in 1979, corresponding to the return of the rusticated youth. The second peak of migration rate occurred in 1984, corresponding with the repeal of Unified Procurement and Marketing of Grain policy in 1985 and its pilot program of "temporary residence certificate" in large cities (i.e. Hubei) in 1984.

Overall, most data conform to a pattern that suggests that agricultural growth usually predicts an industrial growth in the following 1-2 years during the planned economy period, and net migration rate adjusts according to both agricultural and industrial growth.²¹ When the agricultural sector shows steady growth, positive net

²¹ Exceptions also exist. So a definitive conclusion of the logic loop stated in this essay needs a formal model and econometric analysis which I aim to examine in further research.

migration occurred (i.e. year 1958) and contributed to fast industrial growth. But when agricultural growth started to decline, net migration rate soon turned negative to adjust to the rural need (i.e. year 1962). The institutional migration from rural to urban sector (or with reverse direction) was used to adjust to the balanced growth for both the rural and urban sectors.

1.5 *Hukou* reform within the market economy

Contrary to the view that was commonly held, it is not *hukou*'s reform *per se* that lifted the restriction on rural to urban migration. *Hukou*'s reform was preceded by a series of policy changes that made available a massive pool of rural surplus laborers on the one hand, and that created a much more flexible labor market in the urban sector compared with that in the planned economy. *Hukou* was only adjusted so that it can work with other reform policies that allow flexible migration for a new market-economy-based development model.

1.5.1 Preconditions for the *hukou* reform

In a chronicle view, the series of policies that have been implemented presented the inner logic of how the state managed to push massive rural labor force to migrate to urban areas. It was achieved through rural decollectivization first (through the 1982 rural Responsibility System and the 1984 Household Responsibility System in 1984). The decollectivization disciplined these rural migrants to be prepared as the *de facto* urban labor force (through 1982 Custody and Repatriation policy). Then the state reduced the

bargaining power of urban workers with the prepared reserve army of rural migrants through the 1984 Decision on Economic reform and the 1986 Labor Contract System).

1.5.1.1 1982 Agricultural Production System and 1984 Household Responsibility System

In 1982, the state issued the Meeting Minutes of National Agricultural Development, in which it praised the achievements after implementing the Agricultural Production Responsibility System in the rural sector since the 1978 Third Plenum of the Eleventh National Party Congress.²² The Agricultural Production Responsibility System (APRS) has a wider meaning than the later and better known Household Responsibility System (HRS). Under APRS, all types of agricultural work are contracted to individual commune members or individual households. These include work on different types of land, work under different seasons, or detailed work such as fertilizing, spraying pesticides, dry grains, etc. The compensation is either predetermined by the type of work or associated with output when output is measurable.²³

These various contracting formats were experimented within the production brigades as supplementary production to collective agricultural production since the start of the reform. The 1982 document emphasized that more than 90% of the brigades adopted

²² On Jan 1st 1982, the state issued Meeting Minutes of National Agricultural Development, or *Quanguo Nongcun Gongzuo Huiyi Jiyao*. See Chinese version at: http://www.ce.cn/cysc/agriculture/gdxw/201001/15/t20100115_20043473.shtml, retrieved on Mar 2nd, 2016.

²³ See more details at 1980 Document on Issues with Reinforcing Agricultural Production System (http://news.xinhuanet.com/ziliao/2005-02/04/content_2547020.htm), and the section on Labor Compensation in Chronical of Shao Wu City, Fujian Province (<http://www.fjsq.gov.cn/ShowText.asp?ToBook=3180&index=406&>), both retrieved on Mar 2nd, 2016.

various forms of APRS. This contributed to overcoming the free rider issues in the collective production as well as raising incentives and productivity of agricultural production. In addition, restrictions on rural markets and fairs were eased, and peasants were encouraged to engage in the production of cash crops as well as other market-oriented activities. Also, the legal limit on private family plots was raised from 5% to a maximum of 15% of the cultivated land (Meisner 1999, 221). Despite all these market-oriented reform, the 1982 document still spent great efforts explaining why APRS did not contradict the socialist system. The main reasoning was that planning was still the overall guide in the economy while market adjustments were only ancillary. Also, ownership of land and other means of production were still collective. Selling, renting and transferring of contracted land remained strictly prohibited.

In 1984, the state adopted the term Household Responsibility System (HRS) to recognize the nation-wide reform that has already taken place.²⁴ HRS involves a series of policies. First, land was divided so that each individual peasant household enters into contracts with the production team for the use of a given portion of land. Second, farm tools and draft animals were divided among households. Third, households pay the production team a stipulated portion of its output to meet state tax and grain quota obligations (Meisner 1999, 473).

In order to spare the peasants from worrying about frequent policy changes, the time limit for land contracts was extended to 15 years based on HRS, and even longer for the projects that involve longer production cycles such as fruit trees, forestry, and

²⁴ On 1 January 1984, the state issued “Notice Regarding the Agricultural Sector in 1984”, or *Guanyu 1984 Nongcun Gongzuo de Tongzhi*. See Chinese version at: http://www.china.com.cn/aboutchina/data/zgncggkf30n/2008-04/09/content_14685167.htm, retrieved on Mar 2nd, 2016.

wastelands.²⁵ The previous prohibition against transfer of contracted land was released. Instead, the document explicitly “encourage[s] the gradual concentration of land to those who are more able to cultivate farms.”²⁶ The same document also defended the practice of hiring workers by rural enterprises. According to the document, hiring workers does not imply capitalism, as long as a “certain portion of after-tax profit goes to communal property; and goes to workers as compensational payment in additional to wage payment.”²⁷ Moreover, brigade enterprise managers who are responsible for hiring workers in such situations are allowed to receive higher pay than ordinary workers.²⁸ Despite being clearly open to land transfer, land concentration as well as hiring workers, the document was vague on many critical concepts. These included the boundary between the rights owned by the communes and by the individual specializing household (i.e. *Zhuanye hu*), or the limit of wage difference between managers and ordinary workers.

There are three things worth noting here. First of all, individual households now became the *de facto* owners of land although the ownership of the land remains collective in theory. Second, HRS was originally presented as being voluntarily implemented only in the places where collectives failed to operate well in the 1982 document. Yet in fact, it soon became mandatory and was rapidly universalized in the early 1980s. According to Meisner (1999, 473), 98% of peasant households had converted to one form or another of the HRS by the end of 1983. Third, the 1984 document recognized the growing phenomenon that more and more peasants were unable to cultivate their land and had to

²⁵ See Article 1 of the 1984 document.

²⁶ Ibid.

²⁷ See Article 3 of the 1984 document.

²⁸ Ibid.

work for others. But the way it was discussed suggests that this phenomenon was being treated as a given fact rather than a problem to solve.

The rural sector reform did not face strong resistance. One of the key reasons was that new policies for government subsidies were also implemented simultaneously with the APRS. These subsidies included a lowered amount of compulsory quota required from the agricultural sector, a 20% increase in the state price for compulsory grain and a 50% premium for above-quota state purchases, together with a significant price increase for a wide range of other agricultural products (Meisner 1999, 221). Peasants gained huge material compensation through these subsidies. In particular, it was easy for them to produce above-quota amounts of crops largely based on the irrigation system built in Mao's era and cheap fertilizers already accessible in the pre-reform era.²⁹

However, the stimulus effects on the agricultural sector did not last long. Starting from the mid-1980s, agricultural production began to decline. Other problems also occurred such as high inflation, reduced rural social welfare and declining amount of arable land.³⁰ The most important change in the agricultural sector was the rapid growth of socioeconomic inequality. As Meisner observed (1999, 474), the agricultural sector started to show "a class distinction of those who were hiring labors and those who are hired labors gradually appeared." Meisner further described in detail that this is a class distinction between "an elite group of successful entrepreneurs who own machinery or operate commercial and service enterprise, hire wage laborers, and accumulate capital in a diverse variety of private business endeavors" and "the great mass of peasants increasingly

²⁹ Ibid.

³⁰ Ibid.

differentiated by income and function, and ranging from the relatively prosperous to the relatively impoverished.”

1.5.1.2 1982 Custody and Repatriation policy

As a result of the HRS, rural surplus laborers flourish. At the peak of the collective communes, 100 million people were mobilized annually for the “winter works” programs of capital formation and maintenance (i.e. irrigation works). Now these number of people became the surplus laborers “freed” from their rural collectives (Patnaik and Natrajan 2000, Rawski 1979). More and more peasants became unable to afford basic subsistence by cultivating small pieces of land that were distributed to their individual households. Those households with fewer laborers, draft animals or agricultural tools were the ones who were hit first. They appeared less competitive in agricultural production than others so they had to accept side-line work to support their families. Moving to urban areas to find jobs or begging were among the choices (Meisner 1999; Solinger 1999).

Also, rural mechanization could be more fully utilized on collective farms than on small pieces of lands that are distributed to each household under HRS. The fast development of rural mechanization could guarantee either agricultural production increase or the collective benefit increase (i.e. health, education, etc.). Yet for individual households, the only effective way to increase production on the limited land is fertilizer. This could explain the much slower growth in mechanization development after HRS compared to the collective era as is shown in Figure 1.2.³¹

³¹ The agricultural mechanization level also falls for average person. According to the Comprehensive Statistical Data and Materials on 50 Years of New China (*Xinzhongguo Wushinian Tongji Ziliao Huibian*), the employed population in the primary industry shows an overall increasing trend (with mild fluctuations) until the peak in 1991. This measure includes people who are employed in farming as well as forestry, herding and fishery. This is the best available measure to calculate machinery power per person.

Comparing the rate of agricultural mechanization growth before and after the economic reform, we could see that since 1980, the annual growth rate of total power of agricultural machinery has never exceeded 10%. From 1965-1977 (adding one more year before and after the Cultural Revolution), the total growth rate of agricultural machinery power achieved 834%; while the growth rate from 1978-1990, which also spans 12 years, was only 144%. An important implication from this comparison is that the rural migration after the economic reform was not based on a massive improvement of rural mechanization. Lack of rapid rural mechanization makes it difficult to free physical labor without affecting agricultural output level. Yet the land distributed to each household was insufficient to assign work to every laborer. As a result, those who are not needed for the farm work became the surplus labor. They were then forced to migrate to the urban sector to earn subsistence.

As a result of the limited land that households could work on and the bad maintenance of collective work (i.e. building of irrigation, etc.), surplus labor emerged as a severe issue. Data show that 100 to 220 million peasants rapidly became “surplus” rural laborers, among whom some 50 million peasants migrated to urban areas from 1978 to 1988 (Solinger 1999, 18). Figure 1.1 presents the urban migration rate before and after economic reform. We can observe that since 1978, the migration rate remains positive, with the peak (10.7%) occurring in 1984.

The 1982 Custody and Repatriation policy (i.e. *Shourong Qiansong Banfa*) aimed to address the issue of surging migrants who became vagrants due to the lack of urban employment opportunities. Cities established Custody and Repatriation stations to offer

reliefs, education and repatriation for vagrants.³² These stations recorded the names, identities and addresses of these vagrants and their reasons and time for being homeless.³³ The vagrants were then repatriated to their original *hukou* places. The new policy also required that their local government or brigades shall help them solve their living problems so that they do not need to migrate to cities.³⁴ Those having ability to work will be sent to the Placement Farms, or *Anzhi Nongchang*. These are the places to settle those homeless, income-less, long-term vagrants by offering minimum subsistence.³⁵ Those who have problems to be repatriated back and have no ability to work will be sent to social welfare homes or nursing homes and be provided with five protections (i.e. *wu bao*), namely the protections for food, clothes, shelter, medical aid and burial after death.³⁶

The Custody and Repatriation policy is more than just aiming to offer humanitarian aid to the homeless and jobless in the urban sector. These people migrate to cities because they cannot survive by working in the rural sector. Instead of addressing the issue of surplus labor in the rural sector, the state sets the priority of maintaining the fiction that everyone shall have a job in order to live legally in cities by repatriating those people back to the places that they fled from. Usually they are the “incompetent farmers” who had transferred their land to other “competent farmers.” It was also increasingly difficult for them to get hired by rural enterprises with surging unemployment in the rural sector in the 1980s (Solinger 1985, 102). Compared with the repatriation of rural migrants from the urban

³² See Article 2 of the Custody and Repatriation policy, http://china.findlaw.cn/fagui/p_1/191162.html, retrieved on Mar 3rd, 2016.

³³ See Article 8 of the Custody and Repatriation policy.

³⁴ See Article 18 of the Custody and Repatriation policy.

³⁵ See Article 19 of the Custody and Repatriation policy.

³⁶ See Article 20 of the Custody and Repatriation policy.

sector in the planning period, the difference lies in that the peasants repatriated to farm now cannot survive under de-collectivization.

1.5.1.3 1984 Decision on Economic reform and 1986 Labor Contract System

After ensuring that one needs to have a job to live legally in cities, the state started to work to make sure that these urban workers must be “good,” or disciplined workers.

In 1984, the Central Committee of the Chinese Communist Party issued the Decision on Economic Reform (i.e. *Guanyu Jingji Tizhi Gaige de Jueding*), which begins with the statement that “Socialism shall eliminate poverty. We shall not take poverty as Socialism”.³⁷ It then emphasized the importance of providing enterprises with autonomous decision-making power and called for government organs to restrain from intervention.³⁸ On the theoretical side, the document defended the economic reform as not contradicting socialism given the public ownership of the means of production. However, the document made explicit that commodity production and commodity exchange is necessary given China’s unique context with “massive population, inconvenient transportation, information difficulties, imbalanced economic and cultural development among different regions which are all problems hard to solve in the short run”.³⁹

According to the document, the Production Responsibility System implemented in the rural sector shall be applied to the urban sector as well.⁴⁰ This reform has two implications. First, workers’ power over the production process will be shifted

³⁷ See Article 2 of the Decision on Economic Reform, at <http://cpc.people.com.cn/GB/64162/64168/64565/65378/4429522.html>, retrieved on Mar 3rd, 2016.

³⁸ See Article 3 of the Decision on Economic Reform

³⁹ See Article 4 of the Decision on Economic Reform

⁴⁰ See Article 7 of the Decision on Economic Reform

disproportionally to the management level. The document explicitly stated that only the “Manager-Responsibility System” can meet the requirement of detailed division of labor, management for highly productive production in modern enterprises.⁴¹ Second, significant wage differences are allowed based on the different types of work, such as intellectual versus physical labor, complicated versus simple labor, skilled versus unskilled labor, or heavy-load versus light-load labor. The document stated that it is “urgent” to change the current situation of relatively low payment for intellectual labor.” This perspective stands in sharp contrast to the goal of elimination the three differences (i.e. intellectual labor and physical labor, urban and rural area, workers and peasants) under the planned economy.

In 1986, two more documents were issued that were more bold in their wording with respect to the urgency of disciplining workers.⁴² The Temporary Regulation on Labor Contract System in State-Owned Enterprises required a universal implementation of the Labor Contract System. This included various forms such as 5 years long-term workers, 1 to 5 years short-term workers and temporary workers.⁴³ Based on this document, enterprises can terminate the labor contract when 1) workers are found unqualified during the probation period (3-6 months); 2) workers are sick or damaged not because of work and cannot be involved in the original work after health medication; 3) workers disrupt production order or do not conform to reasonable personnel change); 4) enterprises go bankrupt.⁴⁴ If we compare this regulation with the 1952 Decision on Labor Employment

⁴¹ Ibid.

⁴² On 12 July, 1986, the State Council issued Temporary Regulation on Labor Contract System in State-Owned Enterprises, or Guoying Qiye Shixing Laodong Hetongzhi Zanxing Guiding, see: http://www.law-lib.com/law/law_view.asp?id=3786;

On 12 July 1986, the State Council issued Temporary Regulation on Laying off Undisciplined Workers in State-Owned Enterprises, or Guoying Qiye Citui Weiji Zhigong Zanxing Guiding, see: http://library.jgsu.edu.cn/zscq/04/Product4/Law/18_Work/18_Work1234.htm

⁴³ See Article 2 of the Regulation on Labor Contract System.

⁴⁴ See Article 12 of the Regulation on Labor Contract System.

Problems, we will find that workers now can be laid off with the reasons that were strictly forbidden to be used to fire workers in the planned economy.

1.5.2 *Hukou*'s Reform

With all these preset conditions in 1984, large cities such as Wuhan started to loosen the *hukou* regulation by openly issuing Temporary Residence Certificates for rural workers coming to urban cities to work. One year later, this “Temporary Residence Certificate” became applicable in the whole country. Yet grain access was still an issue under the food rationing system for rural migrant workers to maintain even “temporary residence” (6-12 months) in cities and towns. In 1985, the Unified Procurement and Marketing of Grain (UPMG) policy was repealed. This meant that the most effective control over migration through food rationing was lifted. With food becoming accessible in the market, a nationwide implementation of “Temporary Residence Certificate” was announced in 1985.

1.5.2.1 Temporary Residence Certificate and the Repeal of UPMG policy

This newly emerging hostility toward urban workers from 1984 to 1986 is in the context of the adjustment of *hukou* policy and the repeal of UPMG policy. This is because, only when the food rationing constraint was lifted, rural migrants could stay in the urban sectors for as long as they were needed. This created a massive reserve army of workers to compete against the urban sector workers.

The change in the *hukou* system started in some major cities such as Wuhan. As early as May 1983, Wuhan started to adopt the use of “Temporary Residence Certificates” in order to “institute, verify and issue certificates declaring temporary residence for non-native personnel coming to our city [Wuhan] to engage in various kinds of economic activity” (Solinger 1985, 98). In that year, Wuhan’s “temporary and floating population” numbered 222,000 (Solinger 1985, 103). This round of rural-urban migration differed significantly from the floating population in the 1950s in that the migration now was no longer for the sake of central planning of production and distribution operating through “recruitment quota” set by the Labor Department. It was exactly the “blind influx” that the government had fought to prevent from occurring in the 1950s. As a result of this change in the nature of the migration pattern, the Labor Department was no longer responsible for rural-urban migration issues. Rather, it became the responsibility of the Public Security Department (Solinger 1985).

Yet grain access was still an issue under the food rationing system for rural migrant workers to maintain even “temporary residence” (6-12 months) in cities and towns. In 1985, UPMG policy was finally repealed.⁴⁵ In the opening statement of Ten Policies on Stimulating the Rural Economy, the state claimed that UPMG policy was no longer applicable as it now “largely hampers the development of agricultural commodities production and the improvement of economic efficiency.” Instead, a system of contractual order and market sales of agricultural products needs was implemented immediately.⁴⁶

⁴⁵ On 1 January, 1985, CCCPC and the State Council issued “Ten Policies on Stimulating Rural Economy”, or *Guanyu Jinyibu Huoyue Nongcun Jingji de Shixiang Zhengce*, see: http://www.china.com.cn/aboutchina/data/zgncggkf30n/2008-04/09/content_14685741.htm

⁴⁶ See Article 1 of Ten Policies on Stimulating Rural Economy.

With food becoming accessible in the market, a nation-wide implementation of “Temporary Residence Certificate” program was announced in 1985.⁴⁷ According to the regulation, any rural resident 16 years or older planning to stay in the urban sector for more than 3 months needed to apply for a Temporary Residence Certificate (*zan zhu zheng*). Those staying in the urban sector for a relatively longer time due to work needed to apply for a Lodge Certificate (*ji zhu zheng*). With the issuance of this regulation, the restriction on migration was completely lifted. Just within 10 years, the floating population amounted to about 80 million (Chan and Zhang 1999, 833).

There are two things worth noting in this “Provisional Regulation on Temporary Residences in Cities and Towns” issued in 1985. First, the time limit for temporary stay was extended. With the initial experiment in Wuhan in 1983, the policy only allowed six to twelve months of temporary stay. Now one could stay an unlimited amount of time only by receiving a different type of certificate. The term “temporary” in the regulation only refers to the nature of the stay, not the time length of the stay. Second, the occupations of those staying in the urban sector for longer time is explicitly discussed in the document. Those workers are concentrated in the construction, transportation, and other contracted works.

⁴⁷ On 13 July, 1985, the Ministry of Public Security issued “Provisional Regulation on Temporary Residences in Cities and Towns”, or *Guanyu Chengzhen Zanzhu Renkou Guanli de Zanxing Guiding*. See: http://code.fabao365.com/law_263315.html

1.5.2.2 Implementation of Blue-Stamp Urban *Hukou*

The 1992 introduction of the Blue Stamp Urban *Hukou* allowed purchasing of urban *hukou* status. As a result, capital now plays a crucial role in determining who enjoys privileges.

In August 1992, the Ministry of Public Security issued a Circular on Implementation of Locally-Valid Urban *Hukou* Registration. This document started to allow the application of urban *hukou*. To apply for a Blue-Stamp *Hukou*, one needs to pay a large lump-sum fee for urban infrastructural construction (*chengshi zengrongfei*). The specific amount of this fee varied by development level of each specific city and town (Chan and Zhang 1999, 838). After holding Blue-Stamp *Hukou* for certain years (specified by cities independently), one can transfer his or her *hukou* status into becoming a regular urban resident. These residents could then enjoy the same rights and obligations as urban residents.

Needless to say, this right to transfer *hukou* is only enjoyed by those who are relatively rich or powerful. These people include, for instance, relatives of overseas Chinese or Hongkong or Macau investors; domestic investors and their close relatives; persons and their close relatives who, with permission, purchase urban housing at market prices or building urban housing with their own capital; and persons and their close relatives who make significant contributions to the urban economy (Chan and Zhang 1999). This association of urban *hukou* with money value marked the beginning of the *hukou* system being associated with inequality.

1.5.3 *Hukou*'s Role in the Market Economy

Hukou has played three roles in the market economy. First, it assisted in the creation of the reserve army in the urban sector. Second, it assisted the adoption of the Lewis development model under the economic reforms. Third, it reinforced inequality between the urban and rural sectors.

1.5.3.1 Creation of Industrial Reserve Army

In *Capital*, Marx described how the creation of industrial reserve army as a result of a surplus laboring population is a necessary product of accumulation or of the development of wealth for capitalism. Marx also explained how wages are regulated by the expansion and contraction of industrial reserve army. The series of policies implemented first in the rural sector and then in the urban sector resulted in the creation of an industrial reserve army, paving ways for the capitalist development in the urban sector.

The process of creating an industrial reserve army involves two steps in China. From the mid to late 1980s, the urban private sector was not well developed. Therefore, the rural migrants were mainly drawn to the construction and transportation sector, or self-employed as vendors. During this period, rural migrants and urban workers were still working in segregated sectors, and the competition did not start yet. Following the massive lay-offs (i.e. *xia gang*, literally means stepping down the position) in the urban state-owned enterprises in 1990s, the urban private economic sector started to grow and was fully

developed as an integral part of the economy.⁴⁸ Employment in the private sector as a share of the total national non-agricultural labor force grew rapidly from only two percent in 1981 to 18 percent in 1997 (Wu 2006; Garnaut et.al 2001). It is not until then the urban laid-off workers started to face competition in both the full fledging private sector and self-employment opportunities.

The competition from the rural migrant workers became fierce. Compared with the urban laid-off workers, on average rural migrants are younger, physically stronger, more educated on average, and willing to work harder for lower wages (Solinger 2002, 314). The reasons are intuitive. First of all, it is hard for urban workers who previously worked in the state-owned enterprise to get accustomed to the work intensity in the informal sector (i.e. temporary waged worker or self-employed). By contrast, a high proportion of rural migrants already had more than 10 years of experience. As for the physical competitiveness of the rural migrants, the interviewed urban laid-off workers admitted that rural migrants could endure greater hardship: “They can work hard, eat worse food, carry heavier things.” Third, the percentage (12.7%) of rural migrants who were educated at the junior high school level or above was twice high as that (6.7%) for the laid-off urban workers. This may seem counter-intuitive. But in fact, it is often the youngest and the most educated that are able and willing to leave the rural sector to join the labor force.

All of the above advantages combine to produce a 50% higher rate of average labor productivity of rural workers relative to urban workers (Solinger 2002, 314). Yet the average wage for hiring an urban worker (including the legally required benefits) is almost

⁴⁸ In 1999 the National People’s Congress amended the state constitution, proclaiming the private sector a “component part” of the national economy. During the late 1990s the official media constantly trumpeted the significance of the private sector in providing employment for workers pushed aside by the state sector (Solinger 2002).

five times higher than employing a rural worker.⁴⁹ The choice facing private employers is straightforward. Therefore despite some state policies to protect the priority for urban laid-off workers, private employers either would hire rural labor instead or “play on the workers’ eagerness to find new jobs, refusing to give them wages equal to regular workers, though they do just the same work” (Solinger 2002, 313).⁵⁰

As urban workers’ bargaining power gradually declined, employers, intellectuals and skilled labor are paid increasing amounts. Blue-Stamp *hukou* explicitly attracted capital and “competent personnel” into urban area to be the preparatory citizens for special economic zones. The difference between urban and rural sector was no longer on a track toward convergence.

1.5.3.2 Implementing the Lewis Model of Development

An important element of economic development is industrialization, but industrialization can take different forms. In most countries, industrialization follows Arthur Lewis’ dual-sector development model (Fields 2004). In the planned economy, Lewis development model was largely avoided. Yet the market reform led to an alternative development path.

With rural decollectivization first and then a series of labor flexibility policies implemented in the urban sector, a Lewis development path eventually took off in China in the 1990s. However, the Lewis development with Chinese characteristics suggests a

⁴⁹ Ibid.

⁵⁰ According to Solinger (2002, 314), state regulations have divided jobs into three categories. Those jobs that peasants were not permitted to be hired; those that peasants could only be hired if there were an insufficient urban labor supply and those that peasants could be hired.

much less precarious process than what most other developing countries experienced (Wang 2005, 118). This is mostly because China successfully prevented the emergence of large-scale slums in the country's developed metropolitan cities, as occurred in Brazil and India. Yet unlike what much the literature has been arguing (Wang 2005, 27), *hukou* policy alone did not prevent slums. The condition for any existence of slums in large cities was already matured since the repeal of Unified Procurement and Marketing of Grain policy in 1985 when rural people could buy food in cities with cash. And the implementation of Custody and Repatriation policy that forced the slums from occurring in cities since 1982. After this policy was repealed in 2003, the Department of Public Security became in charge of keeping slums invisible from the public sight.⁵¹

The natural consequence of a Lewis type of development is the squeezing of the rural sector, as a result of tolerance towards unbalanced distribution of resources between the urban and rural sector. As Taylor (1988, 760) argues, the major threat to the rural sector is that the most productive workers (i.e. the young, the educated and the skilled) will migrate out of the agricultural sector, leaving older and weaker family members to hold the plots of land as a form of income insurance.

In comparison, in the socialist mode of urban development, the rural sector was not badly treated. Health care and education services had improved rapidly (Zhang and Kanbur 2005). By the late 1970s, bare-foot doctors and clinics were set up in almost all villages. By 1980, the school enrollment rate among rural children reached about 90%. Another important piece of evidence to witness the long-lasting effort the state had made to reduce

⁵¹ Although slums are almost invisible in urban China, United Nations calculated that the actual slum dwellers in China was about 37.8% of the urban population in year 2001. The criteria are access to tap water and bathrooms. See more discussions in Jiang (2006).

inequality between urban and rural sector is the 1965 Direction on the Adjustment of Current Prices.⁵² The direction announced that in the 15 years' history of People's Republic of China, the procurement price of grain has been raised by about 90%, and there is 30% price increase from 1957 to 1964. For the government, the urgent issue at hand is that the unified sale price of grain in urban areas is lower than both the sale price in rural areas and the procurement price from rural area. And this, in the wording of the direction, "causes the unreasonable fact that urban workers can purchase grain at a cheaper price than peasants could, which affects the alliance between workers and peasants." What the state did to reduce urban-rural inequality is first to "raise the unified urban sales price of grain to the same level of the unified procurement price from the rural area"; and then to ensure a "one-yuan increase for every 50 kg grain" which resulted in a total surplus from the price increase of 300 million yuan. Also, for those extremely poor urban areas, government would provide compensation to ensure the affordability of food grain. With a goal of balanced growth of both sectors, the planned economy shows a slow but steady accumulation pattern of both sectors, one that the urban sector was not developed at the sacrifice of rural sector.

It is interesting to look at the solution to this increased draining of the most productive rural workers from the rural sector from the perspective of major official policies and much of the existing studies. The official solution is to encourage seasonal migration of rural labor, that is: rural laborers are welcomed to find urban employment during *nong xian* (slack farming season) but they are encouraged to return farmland to help

⁵² On 19, January 1965, State Council issued the "Direction on the Adjustment of Current Prices", or *Guan Yu Tiao Zheng Dang Qian Shi Chang Wu Jia de Jue Ding*. See Chinese version at: <http://cpc.people.com.cn/GB/64184/64186/66676/4493812.html>

out during *nong mang* (busy farming season). Mainstream scholars, on the other hand, criticized this solution as insufficient to solve the fundamental problem. And their reasoning is that only mechanized farming techniques could compensate for this massive loss of productive laborers. Yet since agricultural mechanization is more effective for large land areas, the government should allow the selling of land-use rights between households. This would permit more effective utilization of rural mechanization on the consolidated land area (Taylor 1988, 761). It is ironic to see that the advantages of farming on large land areas instead of small plots was realized in this context. This is after a nation-wide decollectivization campaign.

1.5.3.3 Reinforcing the Urban-Rural Inequality

Hukou is often associated with protecting urban privileges. This association originated from the planned economy, when urban workers were guaranteed full employment and social benefits related with their employment. These benefits included free compulsory education for children, free or subsidized health care and housing (Zhang and Kanbur 2005). In the rural sector, healthcare and education services were also provided but with lower quality than in the urban sector. Healthcare services were provided with a focus on preventive rather than curative measures. Education services were provided at the commune level.⁵³ The results were rather successful, as is discussed in Section 5.3.2. However, although social benefits are much improved in the rural sector, the physical hardship innately associated with agricultural work still suggest to many an inferior status

⁵³ Ibid.

of the agricultural sector compared to the industrial sector. So although it was actually the UMPG policy that effectively controlled migration in the planned economy, *hukou*'s role of civilian registration, and therefore its assistance in migration control, made it a common target for critique regarding protecting urban privileges.⁵⁴

After the market reform, the nature of the urban privileges changed. Since the urban labor reform in 1984, the “iron rice bowl” system no longer existed. With decollectivization in the rural sector, rural residents started to leave agricultural work and move to the urban sector to work. So the key difference between urban residents versus rural residents was no longer related to the nature of their work. Now the difference is related to the social resources that rural *hukou* holders have access to in the urban sector, and the wages they are paid in the urban sector compared to urban *hukou* holders. They are lower wages even for the same jobs. Moreover, barriers between urban and rural *hukou* holders were more directly confronted because they are now competing for the same jobs and resources, including water, electricity, transportation, stably priced food in the urban sector.⁵⁵

Furthermore, the family separation issues related with the strong mobility control under the planned economy were intensified after the market reform. This was largely due to *hukou*'s role of reinforcing urban- rural inequality. In the planned economy, control of population mobility served both production and distributional purposes. Of course, the urgent need to balance the population between the two sectors through strict imposition of the *hukou* system created problems. For example, policies had been revised gradually to guarantee the reunion of workers and cadres family through an annual two-to-three weeks leave at state expense instead of an automatic migration of family members to the urban

⁵⁴ See discussion in Section 3.

⁵⁵ See relevant discussion for Solinger 1999, page 112.

areas.⁵⁶ But problems still existed for long-distance separated couples and families when only one member is recruited by the urban state sector. According to Cheng and Selden (1994, 661), six million of China's 24 million state sector workers and employees lived at a distance from parents, spouses or both in 1957. This arrangement is indeed inhumane. Yet besides the importance of controlling population mobility, one could also argue that this arrangement limits the privilege of urban workers and cadres. If, according to the current discussion, urban workers and cadres already enjoy some privileges over peasants, it would be more unfair when they can bring family members to urban areas immediately after they were hired in the industrial sector.

Unsurprisingly, this seemingly “non-humanitarian” arrangement induces resentment from the related people. That is why one of the first things that the state did in the beginning of the reform era was to revise the *nong zhuan fei* policy (transfer from agricultural to non-agricultural *hukou* status) mainly to ease the process for the reunion of those long-time separated couples. The state also rehabilitated those purged cadres and intellectuals with their families (Chan and Zhang 1999, 834). This policy was welcomed by professionals and cadres that had experienced family separation. However, the extent of family separation actually worsened during the market economy period. Hundred millions of peasants were forced to leave their land to earn a living. The left-behind children in rural China amounted to 23 million in 2000 (Zhou and Duan 2006).

⁵⁶ On 16 November 1957, “Provisional Regulations Governing Home Leaves and Wages of Workers and Employees”.

1.6 Conclusion

In this paper, I examine the *hukou*'s functions in both the planned economy and the market economy. While a range of existing studies attribute China's urban-rural inequality to the *hukou* system in general, I identify the policies, other than *hukou*, that played crucial roles in controlling rural to urban migration and for protecting the privileges associated with the urban sector.

A review of the experimental policies regarding population and labor employment control since 1951 before the official launch of *hukou* system suggests that civilian registration is not new in China. Rather it can be traced back to the 11th century. However, the distinctive feature of the *hukou* system comes from the broader economic system it is operating under. In the planned economy, *hukou* played important roles in civilian registration, migration control and employment regulation. I emphasize that the Unified Procurement and Marketing of Grain policy was the actual policy that effectively controlled the rural-to-urban migration, with *hukou* only playing a secondary role. The employment regulation function of *hukou* was specifically designed to meet the needs of balanced growth of both rural and urban sectors. The privileges of the urban sector in the planned economy was associated with the nature of the work, with the physical hardship of the agricultural work being considered inferior to jobs in the urban factories. Education and health care services were improving rapidly with successful results in the rural sector. Therefore, access to social resources were not the key dividing areas for urban and rural residents in the planned economy.

The *hukou* system seemed to be an obstacle to the market reform in the sense that it binds the rural labor force on their land. But the true obstacle to the reform is not the

hukou system alone, but the planned economy within which the *hukou* system is operating. In that sense, the repeal of the Unified Procurement and Marking of Grain and reducing urban workers' bargaining power is more important in promoting market reforms than the *hukou* system. My study of the policies from 1982 to 1985 shows how the government, step by step, generated a massive pool of surplus laborers in the rural sector, and broke the "iron rice bowl" system in the urban sector, thus creating the supply and demand conditions for a massive rural to urban migration. This process continues at present. All these policies preceded *hukou*'s first adjustment, i.e. Temporary Residence Certificates and the second adjustment, i.e. the Blue-Stamp *Hukou*. This evidence refutes the view that it was *hukou*'s reform *per se* that lifted the restriction on rural urban migration. The nature of the urban privileges has also changed. Not all urban residents are now employed in the public sector that provided free and subsidized health care services and housing, as in the planned economy. Now money capital and human capital play major roles in the accessibility to social resources.

As a result, although urban and rural residents now both have the freedom to migrate within the market economy, they have paid high costs for this freedom of movement. Urban residents now have lost their guaranteed work and associated benefits, while rural residents lost their access to local education and health care services. They also lost their freedom to live in the rural sector because they can no longer live by merely doing agricultural work. Social resources have been minimized, as the rural sector has been squeezed, in order to further develop the urban sector.

The overall implication of this study is that the interacting effects of the *hukou* and the economic system, rather than *hukou* alone, should be the analytical focus to

address important development topics such as industrialization, urbanization, spatial and social inequality. This finding contributes to the understanding of policy discussion of *hukou* in the context of the overall development model in China.

1.7 Bibliography

Alexander, P. and A. Chan (2004). "Does China Have an Apartheid Pass System?" *Journal of Ethnic and Migration Studies* 30(4): 609-629.

Andreas, J. and S. Zhan (2015). "Hukou and land: market reform and rural displacement in China." *The Journal of Peasant Studies*.

Brown, J. (2012). *City versus countryside in Mao's China*. USA, Cambridge University Press.

Chan, K. W. (1988). "Rural-urban migration in China, 1950-1982: estimates and analysis." *Urban Geography* 9(1): 53-84.

Chan, K. W. (1992). "Economic growth strategy and urbanization policies in China, 1949-1982." *International Journal of Urban and Regional Research* 16(2): 275-305.

Chan, K. W. (1994). *Cities With Invisible Walls: Reinterpreting Urbanization in Post-1949 China*. Hong Kong, Oxford University Press.

Chan, K. W. (1996). "Post-Mao China: A Two-Class Urban Society in the Making." *International Journal of Urban and Regional Research* 20(1): 134-150.

Chan, K. W. (2001). "Recent Migration in China: Patterns, Trends, and Policies." *Asian Perspectives* 25(4): 127-155.

Chan, K. W. (2003). *Migration in China in the Reform Era: Characteristics, Consequences, and Implications*. *The Chinese Development Miracle: Origins, Transformation, and Challenges*. A. So. Armonk, M.E. Sharpe: 111-135.

Chan, K. W. (2004). "Chinese Hukou reforms and rural-urban migration." *China Labor Economics* 1: 108-123.

Chan, K. W. (2009). "The Chinese Hukou System at 50." *Eurasian Geography and Economics* 50(2): 197-221.

Chan, K. W. (2010). "A China Paradox: Migrant Labor Shortage amidst Rural Labor Supply Abundance." *Eurasian Geography and Economics* 51(4): 513-530.

Chan, K. W. (2010). "The Global Financial Crisis and Migrant Workers in China: There is No Future as a Labourer; Returning to the Village has No Meaning." *International Journal of Urban and Regional Research* 34(3): 659-677.

Chan, K. W. (2010). "The Chinese Household Registration System and Migrant Labor in China: Notes on a Debate." *Population and Development Review* 36(2): 357-364.

Chan, K. W. and W. Buckingham (2008). "Is China abolishing the Hukou System." *The China Quarterly* 195: 582-606.

Chan, K. W. and F. Cai (2000). *The Political Economy of Urban Protectionist Employment Policies in China*. Working Paper Series, Chinese Academy of Social Sciences Institute of Population Studies.

Chan, K. W., et al. (1999). "Hukou and Non-hukou Migrations: Comparisons and Contrasts." *International Journal of Population Geography* 5(6): 425-448.

Chan, K. W. and X. Xu (1985). "Urban Population Growth and Urbanization in China since 1949: Reconstructing a Baseline." *The China Quarterly*(104): 583-613.

Chan, K. W. and L. Zhang (1999). "The Hukou System and Rural-Urban Migration in China: Processes and Changes." *The China Quarterly*(160): 818-855.

Cheng, T. (1991). *Dialectics of contro: the household registration (hukou) system in contemporary China*. Dept. of Sociology, State University of New York at Binghamton. Doctoral Thesis.

Cheng, T. and M. Seldon (1994). "The origins and social consequences of China's hukou system." *The China Quarterly*(139): 644-668.

Christiansen, F. (1990). "Social division and peasant mobility in mainland China: the implications of hukou system." *Issues and Studies* 26(4): 78-91.

Dutton, M. R. (1992). *Policies and Punishment in China*. Cambridge, Cambridge University Press.

Fan, C. C. (2008). *China on the Move: Migration, the State, and the Household*. New York, Routledge.

Fields, G. S. (2004). *Dualism in the labor market: A perspective on the Lewis model after half a century*. Retrieved [insert date] from Cornell University, ILR school site: <http://digitalcommons.ilr.cornell.edu/articles/268/>

- Garnaut, R., et al. (2001). *Private Enterprise in China*, Asia Pacific Press.
- Huang, P. C. C., et al. (2012). "Capitalization without Proletarianization in China's Agricultural Development." *Modern China* 38(2): 139-173.
- Huang, Y. (2001, June 26th, 201). "Hukou system cannot be repealed at this moment." Retrieved April 16th, 2013.
- Jiang, L. (2006). "Living Conditions of the Floating Poluation in Urban China." *Housing Studies* 21(5): 719-744.
- Ka, C.-M. and M. Seldon (1986). "Original Accumulation, Equity and Late Industrialization: The Cases of Socialist China and Capitalist Taiwan." *World Development* 14(10/11): 1293-1310.
- Knight, J. and L. Song (1999). *The Rural–Urban Divide: Economic Disparities and Interactions in China*. New York, NY, Oxford University Press.
- Kotz, D. M. and A. Zhu (2011). "The Dependence of China's Economic Growth on Exports and Investment." *Review of Radical Political Economics* 43(1): 9-32.
- Li, T. (2012, June 27th, 2012). "Hukou system cannot be repealed." Retrieved April, 2013.
- Lin, Y., et al. (1994). *Zhongguo de qiji: fazhan zhanlue he jingji gaige* (The China Miracle: Development Strategy and Economic Reform). Shanghai, Shanghai renmin chubanshe (Shanghai People's Publisher).
- Mallee, H. (1996). "China's household registration system under reform." *Development and Change* 26: 1-29.
- Mallee, H. (1996). "Reform of the hukou system." *Chinese Sociology& Anthropology* 29(1): 3-14.
- Naughton, B. (2007). *The Chinese Economy*. Cambridge, MA, MIT Press.
- Patnaik, U. and S. Natrajan (2000). "Output and Employment in Rural China: Some Post-Reform Problems." *Economic and Political Weekly* 35(38): 16-22.
- Potter, S. H. (1983). "The Position of Peasants in Modern China's Social Order." *Modern China* 9(4): 465-499.
- Qin, H. (2013). "Three kinds of inequality behind the hukou system." Retrieved Jan 30th, 2013.
- Rawski, T. G. (1979). *Economic Growth and Employment in China*. Published for the World Bank, Oxford University Press.

Ren, X., et al. (1996). "China's Registration Taboo." *Chinese Sociology & Anthropology* 29(1): 15-26.

Solinger, D. (1995). *The floating population in the cities: chances for assimilation? Urban Spaces: Autonomy and Community in Contemporary China*. Cambridge, Woodrow Wilson Center Press and Cambridge University Press: 113-139.

Solinger, D. (1999). *Contesting Citizenship in Urban China*. Berkeley, CA, University of California Press.

Solinger, D. and K. W. Chan (2002). *The China Difference: City Studies Under Socialism and Beyond*. Understanding the City. J. E. a. C. Mele, Blackwell Press.

Wang, F.-L. (2004). "Reformed Migration Control and New Targeted People: China's Hukou System in the 2000s." *The China Quarterly*(177): 115-132.

Wang, F.-L. (2005). *Organizing through Division and Exclusion: China's Hukou System*. Stanford, CA, Stanford University Press.

Wen, T.-J. (2007). "Jianshe Xinnongcun zhongzai silu bentuhua
Localizing is the key to building the new rural society." *Jiansu Rural Economy*(2).

White, L. T. (1977). *Deviance, modernization, rations, and household register in urban China*. *Deviance and Social Control in Chinese Society*. A. A. Wilson, S. L. Greenblatt and R. W. Wilson. New York, Praeger.

Whyte, M. K. (2010). *One country, two societies: rural-urban inequality in contemporary China*, Harvard University Press.

Wu, H. X. (1994). "Rural to Urban Migration in the People's Republic of China." *The China Quarterly*(139): 669-698.

Wu, X. (2006). "Communist Cadres and Market Opportunities: Entry into Self-employment in China, 1978-1996." *Social Forces* 85(1).

Wu, X. and D. J. Treiman (2004). "The Household Registration System and Social Stratification in China." *Demography* 41(2): 363-384.

Yu, D.-P. (2002). *Changxiang shehui: cong geli zouxiang kaifang: zhongguo huji zhidu yu hujifa yanjiu*
Urban and rural society: from separation to open-up: studies on the China Household Registration System and Law. Jinan, Shandong People's Publisher.

Zhang, Q. (1988). "Basic Facts on the Household Registration System." Chinese Economic Studies 22(1).

Zhang, S. (2013). Repeal and hukou system and let peasants freely enter the cities. Beijing Morning Newspaper. http://cq.ifeng.com/world/detail-1_2013_04/10/700610_0.shtml.

Zhang, X. (2005). "Spatial Inequality in Education and Health Care in China." China Economic Review(16): 189-204.

Zhou, F. and C. Duan (2006). "Literature Review Regarding the Left-Behind Children." Population Journal(3).

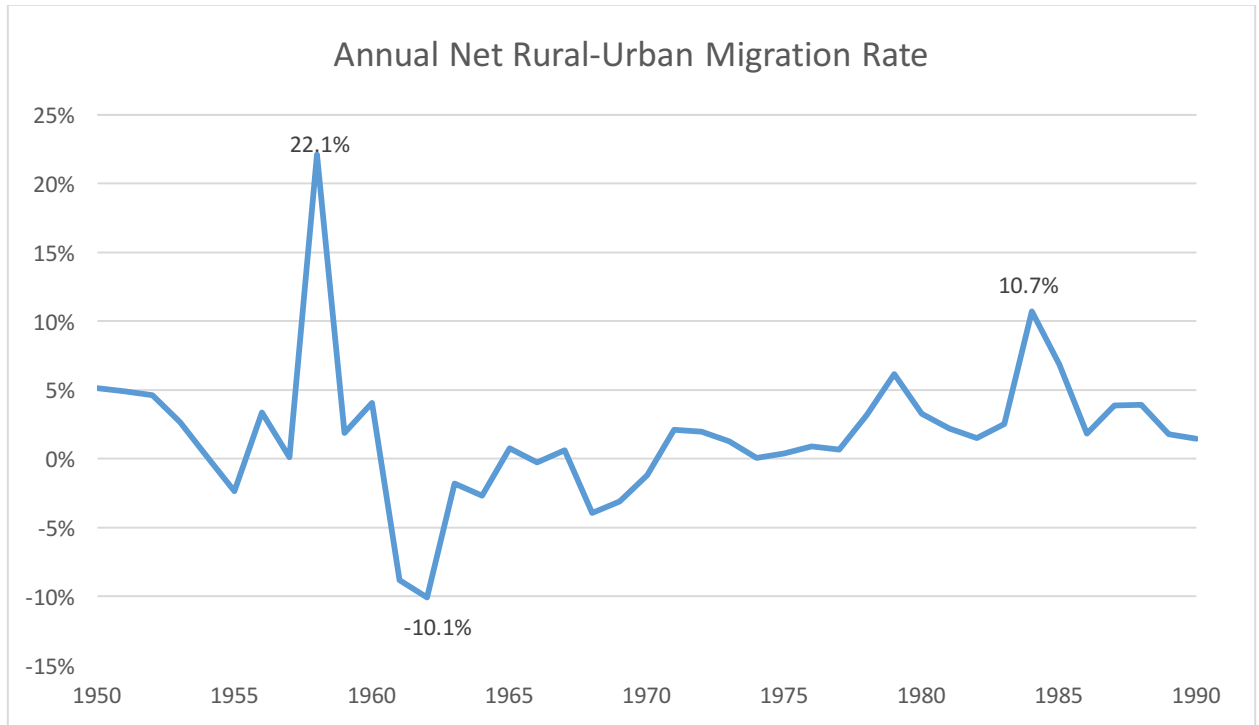
Table 1.1. Growth Rates of Total Industrial and Agricultural Output, Rural Mechanization, and Net Rural-Urban Migration Rate, 1950-1980 (continued onto next page)

Year	Growth rate of Total Industrial Output	Growth rate of Total Agricultural Output	Growth rate of rural mechanization (original)	Growth rate of rural mechanization (compounded annual growth rate)	Net Rural- Urban Migration Rate
1950	NA	NA		NA	5.1%
1951	NA	NA		NA	4.9%
1952	NA	NA		45.8%	4.6%
1953	36.5%	10.2%		45.8%	2.7%
1954	13.0%	3.7%		45.8%	0.1%
1955	3.5%	7.4%		45.8%	-2.3%
1956	17.5%	5.4%		45.8%	3.4%
1957	20.6%	-3.1%	559.8%	45.8%	0.1%
1958	53.0%	3.7%		44.2%	22.1%
1959	29.9%	-13.9%		44.2%	1.9%
1960	5.5%	-11.2%		44.2%	4.1%
1961	-36.3%	29.5%		44.2%	-8.8%
1962	-10.1%	2.7%	523.6%	44.2%	-10.1%
1963	12.4%	9.8%		13.2%	-1.8%
1964	26.1%	12.4%		13.2%	-2.7%
1965	18.5%	16.5%	45.2%	13.2%	0.7%
1966	18.7%	7.8%		14.5%	-0.3%
1967	-16.0%	1.7%		14.5%	0.6%
1968	-10.0%	1.7%		14.5%	-3.9%
1969	27.7%	1.4%		14.5%	-3.1%
1970	32.3%	7.8%	97.1%	14.5%	-1.2%
1971	11.9%	4.2%		30.2%	2.1%
1972	6.8%	0.1%		30.2%	2.0%
1973	8.3%	9.7%	120.9%	30.2%	1.3%

1974	1.0%	4.2%	24.0%	24.0%	0.0%
1975	14.9%	2.7%	26.1%	26.1%	0.4%
1976	-3.2%	-0.4%	15.4%	15.4%	0.9%
1977	13.9%	-2.6%	18.9%	18.9%	0.7%
1978	17.1%	8.1%	14.5%	14.5%	3.2%
1979	10.1%	23.6%	13.9%	13.9%	6.1%
1980	12.8%	8.0%	10.2%	10.2%	3.3%

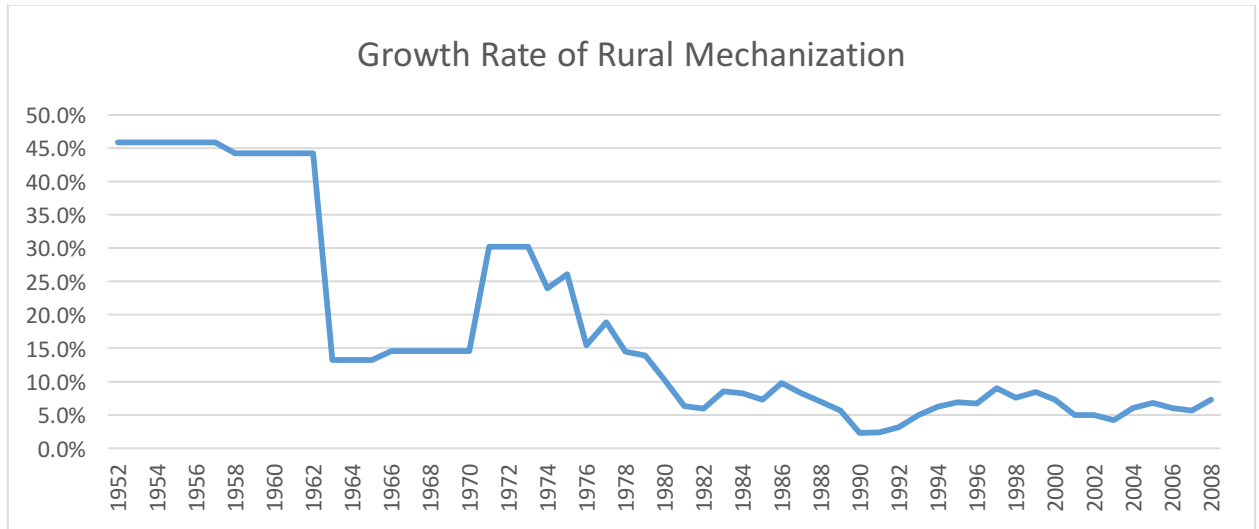
Source: China Statistical Yearbook 2012.

Figure 1.1 Net Rural-Urban Migration Rate 1950—1990



Source: Methodology was discussed in details in Wu (1994).

Figure 1.2. Growth Rate of Rural Mechanization 1952 to 2008



Note: Rural mechanization is measured by the total power of agricultural machinery (kilowatt). The growth rate for year 1952-1973 is calculated as the compound annual growth rates based on the information on the available years.

Source: China Statistical Yearbook (2012).

CHAPTER 2

DOES THE FORM OF BORROWING AFFECT INVESTMENT PATTERNS? EVIDENCE FROM CHINA 1979-1989

2.1 Introduction

The importance of rural finance has been widely acknowledged in the rural development literature. The availability of rural credit is often assumed to have substantial positive impacts on agricultural investment as well as agricultural growth. However, the links among credit, investment and growth are not always straightforward. This is because rural credit can have different sources and can take various forms. For example, credit from institutional sources and private sources are associated with different interest rates which will affect the repayment behavior. Sometimes different institutions will impose specific conditions for the loans they are making. These conditions will in turn affect how borrowers spend their loans. At the same time, investment can also take many forms. While a small amount of loans can only be used to invest in agricultural inputs or small machinery tools, large loans can be used to invest in large-scale projects such as infrastructure building. These different types of investments will have their distinct implications for the loan effectiveness and agricultural growth.

However, most rural finance studies have been focusing on the supply side with specific attention on availability of credit. This quantity perspective is valuable but incomplete. There are also other important perspectives that deserve examination. One example of an understudied perspective is the myriad forms borrowing rural credit takes.

Missing the perspective of borrowing forms risks overlooking the link between borrowing patterns and agricultural loan effectiveness. In this paper, the term

“agricultural loan effectiveness” refers to whether loans are being channeled effectively to contribute to the long-run sustainable development of the agricultural sector. If we can understand how different borrowing patterns might lead to different investment behavior, we might better understand why some kind of lending practices are successful while others are not. We might also understand the way through which production is organized influences investment behavior from the credit demand side.

This essay compares the different agricultural investment patterns when credit is borrowed on a collective basis versus on an individual basis. I construct a model of agricultural investment explained by factors of income, weather and geography as well as and the form of borrowing. Specifically, I use a two-way fixed-effects model for the estimation based on a panel data on the ratio of agricultural credit borrowed on individual basis versus on collective basis (the IC ratio), irrigation, income and weather, covering 11 years and 28 provinces in China. I use irrigation to represent the type of investment that involves a slow yet long-run reward for sustainability, and fertilizer to represent the investment that aims for an immediate return, but can be short-sighted in nature as it is inconsistent with agricultural sustainability.

I find that on the same income and loan level, more loans made to individuals versus to collectives (i.e. a higher IC ratio) will lead to a lower level of investment in irrigation building and maintenance work. Correspondingly, more loans made to individuals versus to collectives (i.e. a lower IC ratio) will lead to a much higher investment in fertilizer use. Based on these results, I argue that the forms of borrowing (i.e. on a collective or individual base) matters significantly in decisions regarding agricultural investments. Collective-based agricultural lending tends to be channeled to investment that contributes

to more sustainable agricultural development yet with returns only in the intermediate or long run.

The remaining sections of the paper are organized as follows. In section 2, I review the existing literature on rural finance. I show that despite two streams of literature that modestly engage with forms of borrowing, the majority of existing studies has not sufficiently studied how different forms of borrowing affect investment patterns. I also introduce the history of China's rural finance development and argue that the particular decollectivization history provides a real-world case of transformation in the forms of borrowing. In section 3, I introduce the specifications of the models that I use to test my hypotheses about the relationship between the forms of borrowing and agricultural investments. I also discuss the reasons behind choosing irrigation and fertilizer as two representative types of investments that are different in their implications for sustainable development. In section 4, I discuss the data sources and provide some descriptive statistics for the key variables. In section 5, I present the main results from my estimation exercises. I also discuss about the implications of the results in details. Section 6 concludes the paper.

2.2 Background and Literature Review

2.2.1 Literature Review

A large body of empirical evidence suggests that increasing access to rural credit leads to higher levels of agriculture-related investment (Binswanger and Rosenzweig 1986; Feder et.al 1992; Binswanger et.al 1993; Rosenzweig& Wolpin 1993; Dinar& Keck 1997; Foltz 2004; Petrick 2004; Binswanger 2006; Mohan 2006; Kohansal et.al

2008).⁵⁷ These case studies have covered a range of countries, including India, China, Columbia, Tunisia, Poland and Iran. However, not all types of agricultural investment have positive associations with agricultural growth under all circumstances. For example, agricultural investment can be publicly or privately funded. Such investment can aim at infrastructure building such as irrigation facilities or roads, as well as raw materials such as seeds or fertilizers. At the same time, agricultural work can be organized by small households or by large collectives. The impact of investment varies with different conditions. Some empirics suggest that public investment in the form of fertilizer subsidies shows negative correlations with agricultural growth in the cases of smallholder farmers.⁵⁸

Also, credit supply does not necessarily alleviate the credit constraint issue in the Chinese case. Rural credit constraint, defined as borrowers who indicated a desire for more credit and the non-borrowers who responded that they could not obtain credit, has been recorded in the literature since the late 1980s (Feder et.al 1989, 1990, 1991) and throughout the literature in the 1990s and 2000s (Park et.al 1997; 2001; Du 2002; Brandt et. al 2004; Tsai 2004; People's Bank of China and China Statistics Bureau 2009). Into the 2010s, the problem appears to still exist. Study of He and Li (2011) shows that among 1.2 billion rural households with credit need, about 30% do not have access to credit. Meanwhile, the supply of credit from financial institutions to the agricultural sector has been increasing dramatically. Despite some fluctuations, the total amount of agricultural loan from the the Agricultural Bank of China (ABC) and Rural Credit Cooperatives

⁵⁷ There are some exceptions. For example, Foltz (2004) suggests that the empirical evidence does not support the claim that credit constraints have impinged on agricultural investment in Tunisia.

⁵⁸ See the report of "Models of Agricultural Investment" by Dochas, the Irish Association of Non-Governmental Development Organizations, at <http://www.dochas.ie/Shared/Files/4/dochas-agricultural-investment.pdf>.

(RCCs), the two major institutional sources, has increased more than eight-fold in real terms from 1979 to 1994.⁵⁹ If we take account of the total loans made to the agricultural sector, data suggests that from 1995 to 2009, the loan supply has increased from 89.9 billion to 739.17 billion yuan (at 1978 price level), a significant nine-fold increase.⁶⁰

The ambiguous relations among agricultural credit, investment and growth suggest the importance of studying what we can term “agricultural loan effectiveness.” In this paper, the term “agricultural loan effectiveness” refers to whether loans are being channeled effectively to contribute to the long-run sustainable development of the agricultural sector. This paper approaches the “agricultural loan effectiveness” issue from the perspective of the form of borrowing. The forms of borrowing refer to borrowing on a collective basis versus on an individual basis. This perspective has its theoretical and empirical basis within the existing literature.

There are two streams of studies touching upon the topic of the borrowing forms. The discounting and time preference literature offer some theoretical elaborations on how public investment involves a lower social discount rate than private investment. The conventional wisdom is that given two similar rewards, humans show a preference for one that arrives sooner rather than later (Solnick et al 1980; Thaler 1981; Millar and Navarick 1984; Benzion et.al 1989; Green et. al 1994; Kirby and Herrnstein 1995; Pender

⁵⁹ The total agricultural loans from Agricultural Bank of China (ABC) increased from 9.9 billion RMB in 1979 to 51.2 billion yuan in 2005, while the agricultural loans from Rural Credit Cooperatives (RCCs) increased from 2.9 billion yuan in 1979 to 42.1 billion yuan in 1994. The Chinese government ceased the publication of China Rural Finance Statistical Yearbook in 1997. The publications were shifted to China Finance Statistical Yearbook, and Agricultural Bank of China Statistical Yearbook. In either publication, the information about Rural Credit Cooperatives as independent lending source has become unavailable. Instead, the transactions in RCCs have been combined into the balance sheets of ABCs.

⁶⁰ China Statistical Yearbook 1996-2010 Table 19-2, Balance Sheet of Credit Funds of Financial Institutions (Funds Uses). This data source does not differentiate loans from public and private institutions. And it does not have data specifically on the loans for agricultural use. This suggests that the loan for the rural sector also includes loans for development of industry and commerce within the rural sector.

1996). The implication of this argument is that when the risks associated with the investments are comparable, investors prefer to make the investment that will give a quick return. Given that social risks affiliated with government projects can be distributed over the entire country and thus are inherently smaller than private risks, public investment will lead to a preference towards rewards in the longer run (Samuelson 1964; Vickrey 1964; Arrow (1965; 1966)). But there is no consensus upon such explanations (Hirshleifer 1961; Jensen and Bailey 1972). The counter-argument is that government projects are still carried out by many private sectors as producers. Thus, the benefits of the projects are received by private household sector as consumers. Therefore, the costs and benefits, as well as the risks occurred to the same group of people. This line of argument leads to the conclusion that there should not be any necessary discrepancy in the discount rates between public and private investment, or that the social discount rate should be at least as high a rate as a similar private project.

This stream of literature does shed some light on the reasons behind different investment patterns. Yet the theoretical discussion is usually too general to be applied to specific cases such as investment from agricultural credit. Also the empirical evidence in the discounting literature is usually produced in laboratories by offering cash rewards to participants. This methodology often suffers from the critique of their external validity (Schram 2005; Roe and Just 2009). Specifically, the laboratory settings are very different from the real world, especially the rural sector that is characterized by high poverty rates. Therefore, one should not expect the behavioral choices made by lab participants to be applicable to the specific cases in the real world.

Research on microfinance is the other stream of literature that engages the discussion about the forms of borrowing.⁶¹ It compares the loan repayment rates from group lending versus individual lending in developing countries. Most studies suggest higher repayment rates when credit is lent to a group of borrowers (Stiglitz, 1990; Varian, 1990; Remenyi, 1991; Besley and Coate, 1995; Ghatak, 1999; Coleman, 2000; Abbink et.al 2006; Karlan 2007; Li et.al 2013; Sinn 2013). One of the key reasons for launching group lending practices in microfinance institutions all over the world is that poor villagers usually do not have access to conventional loans due to their lack of collateral. A group lending practice allows group members to use joint liability as a substitute for collateral. This is a technique through which the poor are supposed to have more access to rural credit. Based on these studies, the higher repayment rates from group lending practices, as compared to the individual lending practices in the microfinance institutions all over the world, can be explained by better information and peer pressures. More specifically, the fact that the borrower groups are usually self-selected by evaluating each other's creditworthiness mitigates the problems of adverse selection and moral hazard from the beginning. Also, the member in the group lending practice tends to repay her loan in order to avoid the social sanction of her peers. The self-selected borrower groups also tend to avoid excessively risky projects, and are more willing to contribute to others' repayment responsibility when loan-supported projects turn out to be unsuccessful. However, there is also empirical evidence that suggests that group lending does not always show advantage over individual lending in terms of loan repayment in all cases over the world

⁶¹ In the microfinance case, the forms of accessing rural credit is more imposed from the supply side. So a more appropriate term should be "forms of lending". This is different from the Chinese case that this essay focuses on.

(Huppi and Feder 1989; Wydick 1999; De Aghion and Morduch 2000; Gine et.al 2006; Karlan and Gine 2007). For example, Huppi and Feder (1989) suggested that successful group lending and credit cooperatives have some common attributes such as homogenous borrowers and bottom-up organization. Other less successful groups or cooperatives do not show advantage in loan repayment compared with small-farmer borrowers.

In addition to the empirical inconsistency for the advantage of group lending for loan repayment, the crucial shortcoming of the microfinance literature in terms of evaluating the forms of borrowing is the targeted indicator: the loan repayment. Since the sustainability of microfinance institutions is one of the key concerns in the real practice, the literature reflects this concern by ambiguously equating high loan repayment rates with success of microfinance operations. However, as Coleman (1999) points out, the primary goal of microfinance institutions as well as village banks in general, should instead be the improvement of overall welfare of the borrowers. If this standard is used for evaluation, one cannot conclude that the microfinance institutions have been operating successfully (Adams and Pischke 1992; Coleman 1999, Bateman 2010). This loan repayment measure gives evidence of the sustainability of lenders, not borrowers, and therefore is unable to provide sufficient information regarding how borrower use the borrowed credit to make investment that is supposed to help improve their financial situation.

This question is important as the way investment is made has an influence on how effectively the loans are being used. And loan effectiveness is reinforced by the level of sustainability of the rural sector. If investment is made in order to have a quick cash return, investors look at ways to get the maximum benefits out of an investment within a

relatively short time. In this case, sustainability will not be a priority. In the case of agriculture, an investment with no sustainability perspective will contribute to the fast decline of agricultural productivity that negatively affects the loan effectiveness in the long run. For example, although fertilizers can significantly improve crop productivity, heavy use of fertilizers was found to have led to significant loss of soil-water and soil organic carbon (SOC) that is crucial for maintaining soil productivity (Huang 2003; Srinivasarao 2014). This means sacrificing sustainable agricultural development in the long run.

The insufficient attention to this critical question of the form of borrowing could be a result of the lack of large-scale data for collective borrowing. This is because most countries under review have not experienced a significant change in the agrarian mode of production that leads to a dramatic change in the form of borrowing.⁶² It is therefore reasonable to expect that these studies do not raise the issue of how the change of mode of production, through its impact on the organization of rural finance, affects the decisions on agricultural investment.

2.2.2 Historical background

China's rural decollectivization in the early 1980s provides a real-world case of transformation in the form of borrowing, from one that is predominantly based on collective borrowing to one based on individual borrowing. The analysis in this paper is based on this unique history in rural China.

⁶² Exceptions exist such as Cater and Olinto (2003).

Agricultural production in China has shifted from one based on large-scale collectives to a small-peasant economy. As a result, the basis of the rural finance organizations in China has changed. Prior to decollectivization, lending mainly took place in the rural credit collectives (RCCs) that operated on the collective communes and corresponded to local demands. In 1976, there were about 50,000 RCCs in operation, reaching the level that there was at least one RCC operating for each rural commune (Lu 2001). After decollectivization, RCCs lost most of their independence when the government re-launched the state-owned agricultural bank, the Agricultural Bank of China (ABC). In fact, half of the RCCs were combined with the business units of banks. Some still kept the names of RCCs but functioned no more than the local branches of ABC. The RCCs also lost their previous local bases, as the production communes were gradually decollectivized. The ABC does very little business directly with agricultural households. Its main focus is on the state agricultural agencies and rural industrial enterprises (Feder et. al 1989). Starting in 1979, ABCs used interest rate and reserve requirement policies to transfer funds from RCCs to ABCs, thus further hampering the RCCs' ability to provide rural credit (Tam 1988).⁶³ As a result, RCCs loosened their ties with the local production basis, and have to work more in line with ABCs. However, as Wen & Jiang (2007) argued, the bank-type rural finance institutions are by nature unable to address the small-amount, low interest return, long-term and high-risk credit demand from the geographically sparse small peasants. By the time RCCs eventually gained their independence from ABC in 1996, the RCCs had already lost their financial significance

⁶³ RCCs are to place 30% of deposits with the ABCs at the annual interest rate of 4 percent. Yet RCCs have to provide their annual deposit interest rates to members within the range of 7 to 8 percent. Also RCCs need to keep 15% of deposits as their own reserves, which leaves only about 50% of the total deposits to be utilized as loans.

and local connections. The major rural finance institutions and the way they operate therefore had undergone a dramatic transformation.

One might expect that given China's agrarian history, studies regarding Chinese rural finance should have probed into the impacts of forms of agricultural lending on agricultural investment. However, this is not the case. Ever since the literature on Chinese rural credit began to appear in the late 1980s, the issue of credit constraint has become the main focus [Tam 1988; World Bank 1988; Feder et.al (1989, 1990, 1991); Park et.al (1997, 2001, 2003); He 1999; Du & Sun 2000; Park & Ren 2001; Xie (2001, 2003); Du 2002; Brandt et.al 2004; Tsai 2004; Chen & Sun 2006; Wen & Jiang 2007; People's Bank of China and China Statistics Bureau 2009; Yang et.al 2010; He and Li 2011; Newman, 2011]. These studies mostly focus on providing empirical evidence on the extent of the credit constraint, as well as explanations for the existence of these constraints. These explanations all took decollectivization for granted and positively evaluated decollectivization as releasing the incentives for higher credit demand that were inhibited in the planned economy. The problem, according to these studies, is the failure of the institutional finance resources to adjust to meet the surging demand. One thing worth noting is that unlike the earlier literature on rural finance (Nolan 1983), very few recent studies have discussed the topic in the context of the development of the agricultural sector. Many discussions were focused too narrowly on comparing the amount of loans available to the rural sector, without examining the effect of those loans. Most of these studies miss the important dimension of who gets the loans, how are loans used, and how these loans assist in promoting sustainable development in the agricultural sector. One possible reason is that the goal of rural credit at present is limited to raising the income of

individual rural households. In the previous era, there was much more emphasis on the welfare of the collective of the whole, for example in building the irrigation systems.

This essay takes advantage of the agrarian change in China that has affected both the ways that rural finance operates and also the agricultural mode of production in general. Specifically, I compare the different agricultural investment patterns when agricultural credit is borrowed on a collective basis versus on an individual basis. Although the case study is about rural China, its implication for understanding agrarian change and rural finance has broader implications, in particular for other developing countries.

2.3 Model Specifications and Methodological Concerns

2.3.1 Models

In this section, I present two econometric models that test how the forms of credit borrowing, collectively versus individually, affect different agricultural investment decisions.

The first model specifically looks at the investment decisions regarding irrigation building and maintenance. All the dependent and independent variables are in their natural logarithm forms. Both provincial (ϕ_i) and year (τ_t) fixed effects are included to control any possible provincial characteristics or specific year effects.⁶⁴ The specification is as follows:

$$y_{it} = \beta * IC_{i\ t-1} + X_{it} + \gamma * IC_{i\ t-1} * Z_{it} + \phi_i + \tau_t + \varepsilon_{it}.$$

⁶⁴ This regression model leaves out the initial level of irrigation investment and fertilizer use for each province in the beginning of year 1979 because these provincial differences are supposed to be captured by the provincial dummy variable ϕ_i .

The dependent variable y_{it} is the effective irrigated area as a share of total sown area in province i and time t . The independent variable IC refers to the ratio of the amount of loan borrowed by individuals over the amount borrowed by collectives. This IC ratio directly measures the degree of loan borrowed on an individual basis versus on a collective basis. It is therefore the key regressor of the model. Adding a subscript, $IC_{i\ t-1}$ refers to the IC ratio in province i and in year $t - 1$, or one year in advance. The reason to use the one-period lagged IC instead of the contemporaneous IC ratio is the existence of time lags between borrowing and using loans. This time lag is especially noticeable between investment decision and implementation regarding irrigation projects. Usually, irrigation building and maintenance works take place in winter when farming work is minimal and surplus labor is available. The irrigation works that conclude in year t usually started in the last several months of year $t - 1$ in the beginning of the winter, after investment decisions were made. Therefore, the completed irrigation work recorded in the official statistics as effective irrigated land should be traced back to the credit borrowed in the previous year. $IC_{i\ t-1}$ here captures this lagged effect between the time when credit is borrowed, investment decisions are made and the time when the investment project is completed and recorded in the official statistics.

X_{it} is a vector of control variables including the real rural income per capita, real loan per capita and climate variables; $IC_{i\ t-1} * Z_{it}$ refer to the interaction terms between the one-period lagged value of IC and all the control variables in X_{it} except the climate variables. This subset of controls denoted by Z_{it} includes the contemporaneous real income level, as well as the contemporaneous and one-period lagged value of real loan. The main reason to include interaction terms between the IC ratio and the specified

controls is that the *IC* ratio imposes different effects on the outcome variable depending on the values of these controls. For example, at a higher income level, one would expect that the households or collectives might be less dependent on borrowing credit to make investment decisions, and therefore the form of loans should show weaker effects on investment outcomes. Similarly, one would expect that with different amounts of available credit, the forms of borrowing might impose different impacts on the eventual investment decisions. All these possible differences in the impacts could be captured through the interaction terms of income and *IC*, as well as loan and *IC*.

Although this model aims to identify the variables that affect irrigation investment, a reverse causality might also be in play.⁶⁵ To take account of this endogeneity issue, I use the one-period lagged value of real income as the instrumental variable for the current income level. The income level of the previous year is correlated with the current income level, but does not correlate with the investment in the current year. Therefore it meets the criteria for an instrumental variable (IV) for the income control variable in the model.

The second model focuses on the investment decisions on fertilizer use. The specification is as follows:

$$y_{it} = \beta * IC_{it} + X_{it} + \gamma * IC_{it} * Z_{it} + \phi_i + \tau_t + \varepsilon_{it}$$

This model specification looks slightly different from that for the irrigation investment, mainly because of the different time horizons to carry out the investment projects. In particular, the key regressor in this model specification is the contemporaneous form of borrowing indicated by IC_{it} as compared to the IC_{it-1} in the

⁶⁵ Binswanger & Rosenzweig (1986) noted how irrigation projects reduce the demand for credit through reducing the seasonality of production and increasing the total production as well as diversifying the risk associated with double cropping.

model for irrigation investment. This is because fertilizer investment can be made immediately. It is reasonable to expect a negligible time lag between when credit is borrowed and when fertilizer is used. Except for this slight difference, this model resembles the previous model for irrigation investment with respect to the use of the dependent variable, control variables, interaction terms, and instrumental variable.

2.3.2 Why use irrigation and fertilizer as the key dependent variables?

Irrigation and fertilizer represent two very different types of agricultural investment. In China, irrigation investments cost about 400 USD per hectare.⁶⁶ Irrigation projects usually take about 1 to 20 years depending on the sizes.⁶⁷ Irrigated plots yield significantly higher level of crop production compared to non-irrigated plots (Huang et. Al 2006). As long as irrigation facilities are well maintained, their benefits to agricultural production stability could last for several decades.⁶⁸

However, one type of irrigation facilities, tube wells, that started to surge among rural households in 1990s needs to be singled out from the irrigation works we focused in this essay. Household tube wells are usually criticized for draining out more water than necessary and for doing more harm than good to agricultural sustainability (Lv 2010). The data coverage in this essay ends in 1989 so the potential negative effects of tube wells do not influence the results.

⁶⁶ These costs are estimated based on the irrigation projects conducted in China in 1999. The money value is expressed in terms of USD of 2000 level. See Database on Investment Costs in Irrigation from the Food and Agriculture Organization of the United Nations, at <http://www.fao.org/nr/water/aquastat/investment/index.stm>, retrieved on April 30th, 2016.

⁶⁷ For example, Miyun Reservoir of 4.3 billion cubic meters in Beijing takes two years to complete the construction. Longyangxia Reservoir of 24.7 billion cubic meters in Qinghai Province takes 16 years to complete the construction.

⁶⁸ The Miyun Reservoir was constructed in 1960 and is still well functioning.

On the other hand, chemical fertilizers cost only about 150 USD per hectare, less than half of the costs for irrigation facilities (Pray et. al 2002). The return from using fertilizer is often immediate, within one crop season. The positive impacts of fertilizers can be best illustrated by the significant improvement in crop yields during the Green Revolution period (Tilman 1998). However, the heavy use of fertilizer also brings detrimental effects on the environment. For example, studies show that fertilizers are often accompanied by significant loss of soil-water and soil organic carbon (SOC) that is crucial for maintaining soil productivity (Huang 2003; Srinivasarao 2014).

I generalize the features of the two types of investment with the recognition of the positive impacts of fertilizers as well as the negative effects of certain types of irrigation facilities. In this essay, I use irrigation to represent the type of investment that involves a slow yet long-run reward for sustainability, and fertilizer to represent the investment that aims for an immediate return, but can be short-sighted in nature as it is inconsistent with agricultural sustainability.

2.3.3 Supply versus demand effect and the relevant endogeneity issue

A shift from collective-based loan to individual-based loan, indicated by a higher value of the IC ratio, may have twofold implications. Following decollectivization, communes and production teams were divided and the dominant mode of production in the rural area became small-household production. As a result, a higher share of credit was demanded by individual households. If this mechanism plays the dominant role, then we conclude that the impact on the IC ratio comes mainly from the demand side. On the other hand, since decollectivization is a policy imposed by the state, one would suspect

that the rural finance institutions show bias towards lending to individuals rather than collectives. If this mechanism is in operation, then there is also a supply-side impact on the IC ratio.

The measure of the IC ratio itself does not distinguish between the supply-side and the demand-side effects. Yet I argue that the dominant impact on the IC ratio comes from the demand side. First, the rural finance reform starting from the 1980s ensures self-sufficiency and profit-orientation as the main goals for rural finance institutions. Collective loans on average have higher repayment rates compared with individual loans.⁶⁹ So profit-wise, one should not expect an institutional bias towards making loans to individuals. Although policy does encourage making loans to individual households to echo the decollectivization campaign, there is no specific requirements regarding what the size of loans should be made to individuals rather than collectives.⁷⁰ Therefore the actual form that any rural loans take should still be interpreted as driven by the borrowers' needs.

Another reason why demand-side effects play a dominant role in the IC ratio is as follows. In theory, individual households can still coordinate the small loans they borrowed individually to make large-scale investments, such as irrigation that requires higher costs. The reality is that these individual households simply did not collaborate when the coordination platforms no longer existed after decollectivization. No matter the rural finance institutions favor making loans to individuals or collectives, in the end it is the level of solidarity among the households. Here the term “solidarity” specifically

⁶⁹ From 1980 to 1989, the average repayment rate of collectively-borrowed agricultural loans is 91.45%, compared with 84.96% for the individually-borrowed agricultural loans. The repayment advantage of collectively loans is more significant from year 1980 to 1986, but was caught up in the last three years of the statistics. See page 73 to 76 in the China Rural Finance Statistical Yearbook 1979-1989.

⁷⁰ See page 54 of the Yunnan Province Rural Finance Chorography.

refers to the possibility of collaborative organization that influences the choice of the forms of borrowing.

The demand-driven form of borrowing in the Chinese case contrasts with that in the microfinance practices. In the microfinance setting, banks determine whether loans are made to groups or individuals based on the associated default risks with the two distinct practices. In the beginning of the microfinance history, the dominant lending practice was group-based (Herms and Lensink 2007). Now individual-based lending is also taken by the most well-known microfinance institutions such as the Grameen Bank of Bangladesh and is expected to be gaining a higher share of the microfinance loans in the future (Lehner 2009).

It is tempting to associate the IC ratio with the level of decollectivization, and thus consider the level of decollectivization as a missing variable in the regression analysis. However, these two statistics are very different. Xu (2012) uses a variable called “HRS Adoption” to measure the percentage of production teams which adopted the Household Responsibility System, or the de-facto small-farm production. This statistic was only 0.01 in 1979, and then jumped to 0.98 in 1983, and 0.99 until 1987 when the data are available. This suggests that while there was only one percent of the production teams being decollectivized in 1979, the decollectivization was almost complete by 1984. However, the IC ratio shows a different picture. Across the provinces, the IC ratio was, on average, about 0.12 in 1979, and became about 1.55 in 1984, and remained in the range of 1.4 to 1.6 until 1987. This suggests that even when decollectivization is almost complete as when HRS adoption percentage became 0.99, the individual loans at that time consist of only about 60 percentage of the total loans on average. This is because

HRS measures the land ownership following a state-imposed decollectivization policy, while the IC ratio measures the solidarity, or the possibility for collaborative work of the collectives. Collectives with strong solidarity in the collective era still have the coordination network which enable them to borrow and invest on a collective basis, even if lands are mostly distributed to individual households already.

This divergence between the two statistics suggests that the IC ratio is a more accurate measure of the solidarity of the collectiveness compared to HRS which measures the level of decollectivization. The irrelevance between the two variables also suggest that the concern for the missing variable is invalid.

2.4 Data Sources and Descriptive Statistics

2.4.1 Panel data selection

The econometric analysis is based on a panel dataset of 28 provinces and 11 years (1979-1989). There are altogether 308 observations for each variable. The time range is chosen to reflect the largest possible variations for the variable IC ratio (i.e. individual versus collective loan) from the available data sources. Prior to 1979, the rural sector in China was still collectively based, and the statistics do not have a category for individual loans.⁷¹ After 1989, The *China Rural Finance Statistical Yearbook* eliminated the category of collective versus individual loans. During 1979 to 1989, rural collectives were gradually dismantled at various rates depending on the historical conditions of

⁷¹ The national Rural Finance Statistics only recorded provincial level data from 1979. Yet provincial level Finance Statistics include agricultural loan data for years prior to 1979 as well and we can use it as a reference for the statistical categories for rural finance in the pre-1979 period. For example, Tianjin Rural Statistics show that from 1949-1978, agricultural loans are broken down to three categories as down payment loans (*yugou dingjin daikuan*), state-run agricultural loan (*guoying nongye daikuan*), and collective agricultural loans (*shedui nongye daiguan*). No individual loans are recorded.

individual collectives. The variation in paces of decollectivization allows the largest possible variation in the IC ratio, although these two indicators are not identical.⁷²

The selection of provinces is mainly based on the data availability. I excluded the data for Hainan and Chongqing due to the administrative change that has affected the data availability.⁷³ Xizang (Tibet) was not included because a series of variables was not available for this province. After excluding these three areas, there are altogether 28 administrative units in the datasets.⁷⁴

2.4.2 Irrigation variable

The dependent variable for the first regression model is the irrigation variable. It specifically measures the share of the effectively irrigated area in the total sown area. The unit of this variable is percentage. The numerator of this measure is the total effectively irrigated area. It refers to the area of level land (in 1000 hectares) that has water sources and complete sets of irrigation facilities to lift and move adequate water for irrigation purposes under normal conditions (Fan and Zhang, 2002). The effective irrigation area is a reasonable proxy for irrigation investment because it contains information of both the investment made to build new irrigation facilities and that made to maintain existing irrigation facilities. This number is then normalized with respect to the sown area (in 1000 hectares) in each province. This is to ensure that neither the irrigation investment nor the fertilizer use level is over-weighted for those provinces with larger geographical

⁷² I discussed the reason in Section 3.3

⁷³ Hainan became administratively a province in the People's Republic of China after 1988, Chongqing after 1997.

⁷⁴ The administrative units include both provinces and autonomously-run cities such as Shanghai which are at the same administrative level as provinces.

areas. The information is extracted from *China Compendium of Agricultural Statistics 1949-2008*.⁷⁵

The effectively irrigated area is a cumulative concept. It is a stock variable that includes not only the flow of irrigation investment in the contemporaneous year, but also the investment and maintenance work in the previous years. In this sense, it is not an ideal measure of irrigation investment for any given year. Alternatively, one can use the growth rates of effectively irrigated area to measure the investment flow. However, using growth rates has its own problems. This is because irrigation involves not only the newly irrigated area but also the maintenance of the already irrigated area, both requiring investment in irrigation. While a zero growth rate of the effectively irrigated area suggests zero investment in irrigation, it significantly underestimates the the actual investment because it cannot capture the investment made for irrigation maintenance work.⁷⁶ The maintenance work involves both labor inputs which are not acknowledged in the statistics, and also the investment in purchasing materials that are needed for building irrigation facilities in money units. If there are reliable statistics for the depreciation rate of the irrigation facilities, we can use the depreciation data and the level measure of effectively irrigated area to calculate the actual net investment for year. However, such statistics are not available. Therefore, even a growth rate measure cannot capture the actual net investment flow that we are interested in.

⁷⁵ Xin Zhongguo Nongye 60 Nian Tongji Ziliao. Page 97, Sheet 3-2-3.

⁷⁶ The average expenditure on irrigation maintenance work is estimated to be about 10-20 RMB per *mu* every year. For the total 0.95 billion *mu* effectively irrigated area in China, the maintenance costs are about 14.3 billion RMB (or 2.5 billion dollars) every year. See Establishing Municipal Maintenance Foundation for Small-Scale Irrigation (*Jianli Caizhen Xiaoxing Nongtian Shuili Sheshi Weixiu Jijin*) at http://zx.pinghu.gov.cn/ucms/html/zx/col1401/2013-06/06/20130606165954872181703_1.html, retrieved on April 29, 2016. See Aiming for 60% of Effectively Irrigated Area with Efficient Water Use by 2020 (*Lizhen 2020 nian jieshui guangai mianji zhan youxiao guangai mianji chao 60%*), at <http://politics.people.com.cn/n/2014/0929/c1001-25759350.html>, retrieved on April 29, 2016.

Some studies use the number of pumps (Binswanger et.al 1993; Rosenzweig& Wolpin 1993;Dinar& Keck 1997) as a measure of net irrigation investment for each year. Using physical tools for irrigation certainly is convenient for deducting the net increase in investment, however physical tools are only part of the costs involved in irrigation investment. Material and labor inputs for constructing ponds, drainage, ditch and weirs (*gou, tang, qu, yan*), which are the major irrigation projects carried out by rural collectives cannot be captured by simple statistics such as the numbers of pumps.⁷⁷ Some micro-level analyses use categorical variables to indicate the irrigation status, such as plots that are irrigated by surface water, ground water, both or neither (Huang et.al). Such status variables are also measures of the stock of irrigation facility and are used with similar reasoning that this essay applies to use a stock variable. However, this micro-level survey dataset China National Rural Survey does not cover the key period with the largest variation in individual versus collective loan ratios on which I focus here.

This paper uses the share of effectively irrigated area in the total sown area because it contains the information of all the possible formats of irrigation work including both irrigation construction and irrigation tools purchasing to ensure that the land is effectively irrigated. Also it is a level measure so it does not cancel out the crucial information of maintenance work as in the growth rate statistics. I discuss the regression results when using growth rate statistics for irrigation in Section 5.6 for comparison purpose.

⁷⁷See featured discussion on rural irrigation construction, at <http://news.sohu.com/s2010/dianji395/>, retrieved on April 29, 2016

2.4.3 Fertilizer variable

The dependent variable for the second model is fertilizer use. It measures fertilizer consumption normalized by the size of the sown area. The unit of this variable is kilogram per hector of land. The information is based on *China Compendium of Agricultural Statistics 1949-2008*.⁷⁸ Like the irrigation variable, I also discuss the regression results when using the growth rate statistics for fertilizer in Section 5.6 for comparison purpose.

2.4.4 Key regressor: IC ratio

The most critical independent variable I use in this regression is the IC ratio. The IC ratio is defined as the ratio of individual loans relative to collective loans from formal rural finance institutions.⁷⁹ Exclusion of informal rural finance is based on the fact that until the year 1990, the informal loans are mainly made from family members or relatives. They neither resembled the private loans undertaken at present in terms of market interest rate, nor were they for productive use. By 1990, the loans for productive investment were still predominantly made from state-owned financial institutions. Since this paper focuses on studying rural finance and its impact on rural productive investment, the loan information from institutional sources is more relevant.

I constructed this ratio for each province based on the statistics from *China Rural Finance Statistical Yearbook 1979-1989*. From page 178 onwards, detailed statistics are

⁷⁸ Xin Zhong Guo Nongye 60 Nian Tongji Ziliao. Page 97, Sheet 3-2-3.

⁷⁹ The terms used in *China Rural Finance Statistical Yearbook 1979-1989* are Collective Agricultural Loans (*Jiti Nongye Daikuan*), and Rural Household Loans (*Nonghu Nongye Daikuan*)

available for the constitution of loans from Agricultural Bank of China and Rural Credit Cooperatives for all provinces in China.

Table 1 below presents the IC ratio of each province for the years 1979, 1984 and 1989 (the first, sixth, and the eleventh years respectively). As we can see, IC ratios do not share a common pattern among all provinces. Most provinces experienced a significant increase in the IC ratio between 1979 and 1989 (with the exception of Shanghai and Beijing). This indicates that most provinces in China experienced a significant transformation in the form of borrowing rural credit, from one on a collective basis to one predominantly on individual basis. We can also see that a quarter of the provinces experienced a sharp increase in the IC ratio in the first 6 years and then the IC ratios dropped. The way of organizing the rural finance units reflected the overall mode of production in the rural sector. The variations in the patterns of IC changes are consistent with the variability in the timing and pace of decollectivization across provinces. Some implemented it thoroughly and persistently with the result of a sharp increase in the IC ratio throughout the 11 years of the study period. Some provinces left the rural finance units as a cushion for the fast decollectivization of agricultural production. This is indicated by a mild decrease of IC ratio in the second half the year period of study.

2.4.5 Other regressors

Other independent variables include the income variable, the loan variable, and the dummy variables on climate regions. These are all control variables for the purpose of this exercise.

The income variable specifically measures the inflation-adjusted annual net income per capita of rural households. I collected the data from *China Compendium of Statistics 1949-2008* published in 2010. By definition, the net income of rural households is the total income of rural households minus operational expenditure for rural households, depreciation of productive assets, tax and contract fee for household responsibility system and transfer to family relatives.⁸⁰ Total income includes both income in-cash and in-kind, adjusted by the market price of the “kind”.⁸¹ The operational expenditure, by definition, includes all operational costs that are attributed to that year’s gain, thus including fertilizers, seeds, pesticides for use of that year yet excluding those purchased but were put stock for future use.⁸² According to Binswanger (2006), household income is especially important in affecting the rural agricultural investment. Some other relevant factors can also be reflected in this income control. These factors include the imported food price (Hayami& Kikuchi 1978; Svendsen& Mark 1994; Dinar& Keck 1997); high costs of irrigation equipment and technology (Svendsen& Mark 1994); general profitability from farm work (Binswanger 2006) and other related income factors (Rosenzweig& Wolpin 1993).

The loan variable measures the inflation-adjusted agricultural loan per capita. The data source is constructed from *China Rural Finance Statistical Yearbook 1979-1989*. The reason for including loan as explanatory variable is that the development literature (Binswanger et.al 1993; Rosenzweig& Wolpin 1993; Dinar& Keck 1997) recorded the

⁸⁰ Definition and Calculation of net income for rural household. <http://www.xyded.com/onevs.asp?id=636>

⁸¹ 90% percent of market price for grain and meat ,85% market price for other agricultural-related products were calculated as “in-kind” price, to reflect the difference of in-kind and in-cash income.

http://www.china001.com/show_hdr.php?xname=PPDDMV0&dname=LI6R841&xpos=13

⁸² Definition and Calculation of net income for rural household. http://www.china001.com/show_hdr.php?xname=PPDDMV0&dname=LI6R841&xpos=13

importance of credit constraints in affecting agricultural investments. This is especially true for investments that take much longer time to see effects, such as irrigation investments.

In addition to income level and credit availability, the development literature suggests that climate condition a critical determinant for irrigation investments, including rainfall, temperature and humidity (Dinar& Keck 1997). Detailed information for these climate variables at the provincial level is not available prior to 1986. Therefore, half of the information will be missing if they are to be used. Instead, I construct dummy variables according to the official geographical division based on information on rainfall, humidity and temperature. According to this standard, China is divided into four regions: humid, half-humid, half-drought and drought regions. Since many provinces are located at overlapping regions, the dummies I constructed are humid regions (11 provinces), half-humid regions (4 provinces), humid and half humid regions (6 provinces), half humid and half drought regions (2 provinces), and half drought and drought regions (5 provinces).

2.4.6 Descriptive Statistics

Table 2 summarizes the key variables in the estimation. The ratio of the amount of loan lent to individual households versus lent to collectives, or the IC ratio, averages about 2.13 over the sample period across the provinces. It has increased dramatically, from a mere 0.14 in 1979 to 4.22 in 1989. This pattern indicates that following the decollectivization policy, a rising share of loans were lent to individuals. Those loans are more than four times the amount of loans lent to collectives in 1989. The share of effectively irrigated area in the total sown area increased only slightly, from 32.06% in

1979 to 33.38% in 1989. The fertilizer use per sown area has increased by 77% over the time span, from 149.31 kilograms per hectare in 1979 to 264.74 kilograms per hectare in 1989. Table 2 also shows that the total amount of loans measured by individual household level has increased by a huge amount over the year, while the real income on the per capita level increases at first, and then declined modestly from 1984 to 1989. The summary of weather dummies show that among the 28 provinces in the dataset, humid regions take the highest percentage of 39%, followed by regions covering both humid and half-humid areas which take about 21% of the total land. Regions covering both half-humid and half-drought areas take the lowest percentage of total land, of only 7%.

Table 3 presents the detailed breakdown of key variables by different income and loan quintiles. As we can see, the IC ratio peaked when income is at its 60% quintile level and when loans are at its 80% quintile level. The share of effectively irrigated area in the total sown area peaked when income is at its maximum quintile level and when the amount of loan is at its lowest quintile level. Fertilizer use also peaked when income is at its maximum quintile level, but when the amount of loan is at its 80% quintile level. This summary suggests that different levels of income and loans have different impacts on IC, and the two dependent variables representing irrigation and fertilizer investment. It also implies that a different combination of the income and loan level would predict different values of irrigation and fertilizer investment. This is why we need to separate out the effects of income and loans when considering the relationship between the IC ratio and irrigation/ fertilizer investment in the model. This also explains why I include interaction terms in the model to capture the different combination of income and loan levels.

In Figure 2.1 I present the scatterplots of the IC ratio and the irrigation variable as a preliminary examination of the possible relationship between the two variables. Figure 2 present the scatterplots for IC ratio and the fertilizer variable. Both scatterplots are plotted using the logged value and the pooled sample across years and provinces. A fitted line and also a 95% confidence interval are also presented on the scatterplots to suggest possible relationship of statistical significance.

As we can see, Figure 2.1 shows a negative correlation between the IC ratio and the share of the effectively irrigated area as suggested by a slightly tilted fitted line running from upper left to lower right. Most of the scatterplots are clustered within the 95% confidence interval, implying a strong negative correlation. On the other hand, Figure 2.2 shows a positive correlation between the IC ratio and the fertilizer use per hectare of sown area as suggested by a fitted line running from lower left to upper right. Again, this positive correlation seems quite strong as most of the observations are clustered within the 95% confidence interval.

This preliminary examination suggests that more rural credits borrowed at an individual level is associated with less investment devoted to irrigation building and maintenance. On the other hand, more rural credits borrowed at an individual level is associated with higher level of fertilizer use. However, this association does not imply causality as the scatterplots only show the relationship between two variables without controlling other variables. To strictly examine the impact of IC on the two investment variables, we need to control for other possible effects such as income, loan and climate variables in a fully specified formal model.

2.5 Results and Discussions

2.5.1 Interpretation of coefficients when the dependent variable contains a fraction value

The fact that the irrigation variable is a fraction value between 0 to 100% invites some discussion about the interpretation of coefficients in the regression model. A simple numerical example will show the theoretical foundation of interpreting the change in the dependent variable as a percentage point change. Suppose both the dependent variable and control variable are level values rather than log values, then the coefficient $\beta = \frac{\Delta y}{\Delta x}$ implies that one level increase in x leads to β level change in y . If y is a fraction (i.e. between 0 and 1), then we can rewrite the equation into $100 * \beta = \frac{100 * \Delta y}{\Delta x}$. This rewritten equation suggests that one level increase in x leads to $100 * \beta$ percentage point increase in y . When both the dependent variable and control variables are also transformed to its log form, then the interpretation should be an elasticity change of y as a result of x (percentage change as a result of percentage change). In this paper, the coefficients are thus interpreted as percentage point increases as a result of percentage increases.

Alternatively, one can address the fractional dependent variable by estimating the variables in a fractional response model or a zero one inflated beta models. However, there is no empirical evidence showing that these alternative model specifications are theoretically better than the simple OLS regression model. This essay therefore adopts the simple OLS regression specification.

2.5.2 The upper bound limit on the share of effectively irrigated area does not create problems for the estimations

Several concerns could be raised regarding the value range of the dependent variable in the model, or the share of effectively irrigated area. First, the estimation needs to rule out the possibility that some agricultural land does not need irrigation either due to plentiful and reliable water or crops that do not need irrigation. This is because, if such natural endowments exist widely, one should expect an upper bound for the share of effectively irrigated areas, well below 100%, on the land that is suitable for irrigation. Second, the stagnating growth in the share of effectively irrigated area during 1979-1989 might be explained by an upper bound limit as a result of an already sufficient level of irrigation. In this case, any additional establishment of irrigation facilities only leads to diminishing returns.

There are four main reasons why these concerns do not present serious problems. First, agricultural land is defined as effectively irrigated when it is equipped with basic irrigation facility, and/or with constant water resources, and/or with relatively flat land level, so that the land could be effectively irrigated within the present year. The key idea behind this definition is that the agricultural land could only be categorized as effectively irrigated when it has the capability to endure any unforeseen drought event in the same year. Even if the agricultural land has plentiful and reliable water resources, the water still needs to be channeled out when too much is reserved for future use. Being endowed with plentiful water resources does not suggest that the farmland should be completely rain-fed, or *kaotian chifan*, (i.e. completely depend on the natural forces without any basic facility to prevent or fight for flood or drought events). The 2010 drought in

Yunnan province proved to be out of expectation because Yunnan is endowed with most reliable waterfalls. However, without updated irrigation facilities to accumulate and channel water for future use, it had been struck hard by a historically rare drought.⁸³

Second, the major crops in China, such as rice, wheat, corn, soybeans and tuber crops are all water-dependent.⁸⁴ As a matter of fact, two-thirds of the Chinese crops need to be produced on the irrigated land (Gao 1998). Even for traditionally rain-fed farmland, supplementary irrigation is essential in generating optimal yield even on the (Bello, 2008). Dry-farming is a technique only developed to cope with the fact some land cannot be effectively irrigated so is not ideal. Therefore, the mere existence of non-water-dependent crops do not justify the stagnation of irrigation building and maintenance during the period examined in this paper.

Third, based on the definition of effectively irrigated area, a mere 33.9% of total sown area in 1989 suggests that only one-third of the sown land has the capacity to endure drought and flood events. Even at present, the percentage of effectively irrigated area in rural China is so low that it threatens food security. In 2010, it is estimated that less than half of the sown area in China is effectively irrigated. The Chinese Academy of Science interpreted this as a dangerous sign for drought that could potentially threaten food security and economic stability.⁸⁵ Given the urgent need for irrigated area, a mere

⁸³ The village in Yunnan that is under discussion in this article reported that the only irrigation facility they have was built in 1958, during the Great Leap Forward. Yet due to lack of maintenance, no one dares to use it to accumulate full level of water. Irrigation building is too lagged behind in South West China to endure the historically rare drought weather (*Lishi Hanjian de Ganhan Tianqi Tuxian Xinan Shuili Jianshe Zhihou*), published on March 23rd, 2010, on <http://news.sohu.com/20100323/n271020821.shtml>, retrieved on November 20, 2015.

⁸⁴ China in brief---Agriculture. Retrieved on November 21, 2015, at <http://www.china.org.cn/e-china/agriculture/crop.htm>.

⁸⁵ China Academy of Science, Irrigation building as the key national policy and be prepared for fighting natural disasters (*Jiang shuili jianshe zuowei jiben guoce, wei dikang zaihai zuohao zhunbei*); published on March 23rd, 2010, on <http://news.sohu.com/20100323/n271039548.shtml>, retrieved on November 19, 2015.

increase in the share of effectively irrigated area from 32.1% to 33.9% from 1979 to 1989 does not represent progress. Therefore, the irrigation level in the time period under examination is far from adequate for a populous and land-scarce country like China.

Fourth, methodologically there is a weather control in the model, so that natural differences among provinces (i.e., humid, half-humid, half-drought and drought regions) are controlled in the model.

2.5.3 Effects of IC ratio on irrigation investment

Table 4 summarizes the regression results. They show the coefficients for each control variable. For example, the coefficient of -0.14 for lagged IC in column 2 suggests that after controlling for all other variables listed in column one, a one percentage point increase in the IC ratio from last year leads to a 14 percentage point decrease in irrigation investment. However, note that the control variables also include the interaction terms of lagged IC with income and loans, as shown in column one. The coefficient of lagged IC in this case only reports the partial impact of lagged IC because the rest of the impact from IC has been controlled through its interaction terms with other variables. The same problem applies to the coefficients reported in column 3 and 4 for the analysis on fertilizer use. To fully account for the effect of IC on either irrigation or fertilizer use, we need to take into account its total effect both through the interaction terms and its partial effect reported by the coefficient of non-interaction term of IC. We do that by calculating the marginal effects of IC. The results are presented in Table 5 and Table 6.

Table 5 and 6 report the marginal effects of the key control variables including IC, income and loan variables. Weather, provincial and year effects are not reported but

they are all controlled in the regression analysis. The first row of Table 5 shows the marginal effects of $IC_{i\ t-1}$ on the irrigation investment. To calculate the marginal effect of $IC_{i\ t-1}$, both the coefficient of $IC_{i\ t-1}$, or β , and the coefficient of the interaction terms involving $IC_{i\ t-1}$, or $\gamma_t * Z_{it}$ are taken into account. The results of the marginal effects of $IC_{i\ t-1}$ are presented with income and loan (Z_{it}) setting at their mean values.

As we can see, the lagged IC has a statistically significant negative impact on the irrigation investment in both the basic specification and in the specification including the instrumental variable (IV). At this level, a one percent increase in the one-period lagged IC ratio would lead to 2 percentage point lower share of effectively irrigated area in the total sown area. That is to say, on the same income and loan level, more loans made to individuals versus to collectives will lead to a lower level of investment in irrigation building and maintenance work.

2.5.4 Effects of IC ratio on fertilizer investment

Table 6 presents the regression analysis for fertilizer investment in both its original specification (Model 2) and an alternative specification for robustness check (Model 3). In Model 2 where only contemporaneous effects of IC are considered, the estimation results suggest that the IC ratio has a significant positive impact on the fertilizer use in both the basic specification and in the IV specification. Specifically, a one percent increase in the IC ratio would lead to about a 10 percent point increase in fertilizer use, whether the endogeneity issue is addressed by IV or not.

For a robustness check, I use an alternative specification which includes both contemporaneous and lagged values of IC in the regression model. This is because it is possible that in certain rural areas, borrowing entails a significant time lag between when

the loan was recorded to be lent to the rural households, and when it actually reaches the rural households for any investment. In this specification where both contemporaneous effects and lagged effects are considered, results suggest that a one percent increase in the contemporaneous IC ratio leads to a 6 percent increase in fertilizer use in both the basic specification and in the IV specification. Compared with the first specification, the impact of contemporaneous IC on fertilizer use is weaker in this specification because the partial impact was accounted for through last year's IC ratio, although not with statistical significance. The contemporaneous IC ratio still has the strongest and the most significantly positive impact on fertilizer use compared with other control variables.

2.5.5 Marginal effects of Income and Loan

The marginal effects of income and loan on both the irrigation and fertilizer investment are also worth some discussion. As we can see, the income level (both contemporaneous and lagged) shows negative impact on irrigation investment, although this effect is statistically insignificant. This direction of impact is counterintuitive, as one would expect higher income level leads to higher investment in irrigation. However, the data suggest that the causation runs in the opposite direction. Higher income might be directed to other types of investment, such as purchasing fertilizer rather than to build and maintain irrigation facilities. This is because the rural decollectivization on the one hand weakens the solidarity among individuals, and on the other hand, makes it practically more difficult to cooperate for large-scale irrigation projects. This argument is confirmed by the positive coefficients of income (both contemporaneous and lagged) in the fertilizer model.

The loan effects show similar patterns. The coefficients for the loan variables (both contemporaneous and lagged) are negligible and statistically insignificant for investment in both irrigation and fertilizer. This suggests that compared with the form of borrowing, the amount of borrowing has much weaker impacts on the actual investment.

Overall, the results of this exercise suggest that once the IC ratio, together with weather, provincial and time effects are controlled, income and loan are irrelevant as explanatory variables in determining investment in irrigation and fertilizer. This result is consistent with the main argument of this essay, that the form of borrowing, collective or individual, has a crucial impact on the types of investment.

2.5.6 Alternative measures

Alternatively, I used the growth rate of the effectively irrigated area as the dependent variable in the regression analysis for investment in irrigation. In this specification, I use the level value instead of the log value for the dependent variable because the dependent variable is already a growth rate measure. A level value is easier for interpretation. Table 7 presents the results. As we can see, the marginal effect of the lagged IC ratio has lost its significance in this specification. Even some of the coefficients for the income and loan controls turn negative which is counterintuitive. One reason could be the inaccurate measure of irrigation investment by this growth rate variable as discussed in Section 4.2. Moreover, the R-square declined to below 20%, indicating that this specification is insufficient to capture the relationship between lagged IC ratio and growth rates of irrigation as the dependent variable.⁸⁶

⁸⁶ Whether another specification will capture the effects of IC on the growth rates of irrigation will be studied in further research.

2.5.7 Discussion

The empirical evidence from these regression exercises suggests that collective borrowing leads to a higher level of irrigation investment. As was discussed in Section 3.2, investment in irrigation contributes to the sustainable development of agriculture in the long run as compared to investment in fertilizer use. Therefore, this empirical result also implies that collectives are capable of making decisions that extend beyond individual horizons. This result is consistent with the theoretical elaboration that the social discount rate is lower than private discount rate, and therefore private investors are more inclined towards obtaining rewards in the short run.

Of course, collectives vary in their patterns of operations. Ostrom (2009) summarized some common attributes of successful collectives. They include clear and locally understood boundaries between legitimate users and nonusers, full participation of individuals who are affected by collective choices, monitoring users and resources, etc. China's collectives are also heterogeneous, so not all of them should realize the potential for success. Here I emphasize that when some basic conditions are met, collectives have the capability of making investments that contribute to the sustainable development in the rural sector. These conditions include the sizes of the collectives as well as the accessibility to trusted and organized platforms for production. I argue that the collectives in China during the collective era have met these two basic conditions. This was one of the key reasons that the empirical result in this essay suggests the advantage of collectives over individual households in making investment decisions that meet with the sustainability criteria.

The first condition is that the size of the collectives must be sufficient to ensure the benefits through economies of scale. The average size of a production team, which was the basic accounting unit for collective production, is 20 to 30 households.⁸⁷ This size of collective production can easily take advantage of large-scale machinery, irrigation facilities as well as laborers. For example, Patnaik (1987) documented how tea production requires manuring in the slack season, tea plucking in the busy season, and tea picking with coordinated sequence as its essential labor activities. These activities, as noted by Patnaik (1987), was most efficiently achieved by production teams of several dozen workers rather than by individual households.

The second condition is a trusted and organized platform for production. Compared with the Soviet Union, China's collectivization was achieved with far less social disruption and without drastic economic losses (Nolan 1976). On the contrary, the number of farm animals and the grain output in China increased during and after collectivization (*Ibid*). This condition suggests a much more voluntary and cooperative basis for China's collectives compared with those in the Soviet Union.

These attributes of the rural collectives in China provide the preconditions for their capabilities of utilizing rural credits in order to raise the overall loan effectiveness. This finding also provides a possible explanation for the persistent credit constraint after de-collectivization despite surging credit supply. The changing forms of borrowing had imposed a negative impact on the overall loan effectiveness.

⁸⁷ See the Notice Regarding the Basic Accounting Units for People's Commune (*Zhonggong zhongyang guanyu gaibian nongcun renmingongshe jiben hesuandanwei wenti de zhishi*), released on Feb 14th, 1962. See <http://cpc.people.com.cn/GB/64184/64186/66669/4493583.html>, retrieved on June 13th, 2016.

This finding also sheds light on the explanations towards the disappointing outcomes with respect to the majority of microfinance projects. Collectives do more than make investment decisions, they also have the resources to carry out the investment project collectively. Microfinance borrowers may make group decisions, but they lack the capability to carry out the large-scale projects such as irrigation because eventually they do not have a trusted and coordinated platform for collective production.

2.6 Conclusion

This paper examines the different agricultural investment patterns as a result of the change in the forms of borrowing rural credits. This change refers to fact that the majority of rural credits are borrowed on an individual basis instead of on a collective basis, as a result of the decollectivization taking place in China since the late 1970s. I focus on estimating how this change in the forms of borrowing affect the investments in irrigation building and fertilizer use respectively. The irrigation investment represents the kind of investment that contributes to more sustainable agricultural development yet with returns only in the intermediate or long run. By contrast, the fertilizer investments represent the kind of investment that is aimed for a quick return yet does potential harms to the sustainable development in the agricultural sector.

This paper mainly builds on a two-way fixed-effects model for the estimation, taking account of the endogeneity issue by including the instrument variable for alternative specifications. I find that on the same income and loan level, a one percent increase in the IC ratio from the previous year would lead to a two percentage point lower share of effectively irrigated area in the total sown area this year. On the other hand, a one percent

increase in the ratio of loans made on an individual basis relative to a collective basis would lead to about 10 percentage point increase in fertilizer use.

Based on these results, I argue that the forms of borrowing (i.e. on a collective or individual base) matters significantly in decisions regarding agricultural investments. Collective-based agricultural lending tends to be channeled to investment that contributes to more sustainable agricultural development yet with returns only in the intermediate or long run (such as irrigation). This empirical result also implies that collectives are capable of making decisions that think beyond individual horizon. This is because the rural collectives in China met two basic conditions that allow them to utilize rural credits with relatively better loan effectiveness. They are large enough to achieve economies of scale, and they have a collective production basis which by nature requires coordination and mutual-trust that are crucial in carrying out large-scale project such as irrigation building.

This finding contributes to the understanding of the transition in agricultural mode of production and its impacts on agricultural investment. It suggests one possible explanation for the credit constraint issue in China. It also sheds light on the explanations towards some of the unsuccessful microfinance practices in developing countries.

2.7 Bibliography

Abbink, K., et al. (2006). "Group size and social ties in microfinance institutions." *Economic Inquiry* 44(4): 614-628.

Adams, D. W. and J. D. V. Pischke (1992). "Microenterprise credit programs: Deja vu." *World Development* 20(10): 1463-1470.

Aghion, B. A. r. d. and J. Morduch (2000). "Microfinance beyond group lending." *Economics of Transition* 8(2): 401-420.

- Arrow, K. (1965). "Criteria for Social Investment." *Water Resources Research* 1(1): 1-8.
- Arrow, K. (1966). *Discounting and Public Investment Criteria*. Baltimore.
- Bank, W. (2002). *Empowerment and Poverty Reduction: A Sourcebook*.
- Bardhan, P., et al. (2012). "State-led or Market-led Green Revolution? Role of Private Irrigation Investment vis-a-vis Local Government Programs in West Bengal's Farm Productivity Growth." *Journal of Development Economics*(99): 222-235.
- Barslund, M. and F. Tarp (2008). "Formal and Informal Rural Credit in Four Provinces of Vietnam." *Journal of Development Studies* 44(4): 485-503.
- Bateman, M. (2010). *Why Doesn't Microfinance Work?-- The Destructive Rise of Local Neoliberalism*. New York, Zed Books Ltd.
- Bateman, M. and H.-J. Chang (2009) *The Microfinance Illusion*.
- Becker, G. S. and C. B. Mulligan (1997). "The endogenous determination of time preference." *The Quarterly Journal of Economics*: 729-758.
- Bello, W. B. (2008). "The Effect of Rain-fed and Supplementary Irrigation on the Yield and Yield Components of Maize in Mekelle, Ethiopia." *Ethiopian Journal of Environmental Studies and Management* 1(2).
- Benzion, U., et al. (1989). "Discount Rates Inferred From Decisions: An Experimental Study." *Management Science*(35): 270-284.
- Besley, T. and S. Coate (1995). "Group lending, repayment incentives and social collateral." *Journal of Development Economics* 46(1): 1-18.
- Binswanger, H. P. (2006). *Empowering Rural People for Their Own Development*. Elmhurst Lecture at International Association of Agricultural Economists Conference. Gold Coast, Australia.
- Binswanger, H. P., et al. (1993). "How infrastructure and financial institutions affect agricultural output and investment in India." *Journal of Development Economics* 41(2): 337-366.
- Binswanger, H. P. and M. R. Rozenzweig (1986). "Behavioral and Material Determinants of Production Relations in Agriculture." *Journal of Development Studies*(22): 503-539.
- Brandt, L., et al. (2004). *Are China's Financial Reforms Leaving the Poor Behind. Financial Sector Reform in China*. USA: 204-230.

- Bureau, P. s. B. o. C. a. C. S. (2009). Survey Report on Rural Credit People's Bank, China.
- Carter, M. R. and P. Olinto (2003). "Getting Institutions "Right" for Whom? Credit Constraints and the Impact of Property Rights on the Quantity and Composition of Investment." *American Journal of Agricultural Economics* 85(1): 173-186.
- Coleman, B. E. (1999). "The impact of group lending in Northeast Thailand." *Journal of Development Economics* 60: 105-141.
- Coleman, B. E. (2000). Risk, mutual assistance, and mutual insurance among village bank members. Manila, Asian Development.
- Dinar, A. and A. Keck (1997). "Private irrigation investment in Colombia: effects of violence, macroeconomic policy, and environmental conditions." *Agricultural Economics*(16): 1-15.
- Du, X. (2002). "Conceptual framework of rural finance, Reform of rural finance and Micro-finance." *Chinese Rural Economy (Zhongguo Nongcun Jingji)*(8): 4-9.
- Fan, S. and X. Zhang (2002). "Production and Productivity Growth in Chinese Agriculture: New National and Regional Measures." *Economic Development and Cultural Change* 50(4).
- Feder, G., et al. (1989). "Agricultural Credit and Farm Performance in China." *Journal of Comparative Economics* 13(4): 508-526.
- Feder, G., et al. (1990). "The Relationship between Credit and Productivity in Chinese Agriculture: A Microeconomic Model of Disequilibrium." *American Journal of Agricultural Economics* 72(5): 1151-1157.
- Feder, G., et al. (1991). The Nascent Credit Market in Rural China, Center for Research in Economic Growth, Standard University.
- Feder, G., et al. (1992). "The Determinants of Farm Investment and Residential Construction in Post-Reform China." *Economic Development and Cultural Change* 41(1): 1-26.
- Foltz, J. D. (2004). "Credit Market Access and Profitability in Tunisian Agriculture." *Agricultural Economics*(30): 229-240.
- Gao, Z. (1998). "The development of water management in irrigation, Guangai shui guanli de fazhan qushi." *China Rural Irrigation and Hidroelectriciy, Zhongguo nongcun shuili shuidian*(12).

- Gine, X. (2011). "Access to Capital in Rural Thailand: An Estimated Model of Formal vs. Informal Credit." *Journal of Development Economics* 96(1): 16-29.
- Gine, X., et al. (2006). *Microfinance games*. Yale University Economic Growth Center Discussion Paper.
- Goldstein, M. and C. Udry (2005). *The Profits of Power: Land Rights and Agricultural Investment in Ghana*. Economic Growth Center discussion paper. Yale University and Leibniz Information Center for Economics.
- Green, L., et al. (1994). "Discounting of Delayed Rewards: A Life-Span Comparison." *Psychological Sciences* 5(1): 33-36.
- Hayami, Y. and M. Kikuchi (1978). "Investment Inducements to Public Infrastructure: Irrigation in the Philippines." *The Review of Economics and Statistics* 60(1): 70-77.
- He, G. and L. Li (2011). "Micro-finance in the large-scale commercial bank." *Chinese Rural Economy (Zhongguo Nongcun Jingji)*(5): 21-26.
- Hermes, N. and R. Lensink (2007). "The Empirics of Microfinance: What do we Know?" *The Economic Journal*(117): F1-F10.
- Hirshleifer, J. (1961). "Risk, The Discount Rate, and Investment Decisions." *The American Economic Review* 51(2): 112-120.
- Hoff, K., et al. (1993). *The Economics of Rural Organization: Theory, Practice, and Policy*. New York, N.Y., Oxford University Press for the World Bank.
- Huang, M., et al. (2003). "Effect of Increased Fertilizer Applications to Wheat Crop on Soil-water Depletion in the Loess Plateau China." *Agricultural Water Management* 58(3).
- Huang, Q., et al. (2006). "Irrigation, agricultural performance and poverty reduction in China." *Food Policy*(31): 30-52.
- Hulme, D. (2000). "Is Microdebt Good for Poor People? A Note on the Dark Side of Microfinance." *Small Enterprise Development* 11(1).
- Huppi, M. and G. Feder (1990). "The role of groups and credit cooperatives in rural lending." *The World Bank Research Observer* 5(2): 187-204.
- Jensen, M. C. and M. J. Bailey (1972). *Risk and the Discount Rate for Public Investment. Studies in the Theory of Capital Markets*, Harvard Business School.
- Karlan, D. S. (2007). "SOCIAL CONNECTIONS AND GROUP BANKING." *The Economic Journal*(117).

Karlan, D. S. and X. Gine (2007). "Group versus individual liability: A field experiment in the Philippines." Center for Global Development Working Paper(111).

Khoi, P. D., et al. (2013). "Formal and informal rural credit in the Mekong River Delta of Vietnam: Interaction and accessibility." *Journal of Asian Economics* 26.

Kirby, K. N. and R. J. Herrnstein (1995). "Preference Reversals due to Myopic Discounting of Delayed Reward." *Psychological Sciences* 6(2): 83-89.

Kohansal, M. R., et al. (2008). "Effect of Credit Accessibility of Farmers on Agricultural Investment and Investigation of Policy Options in Khorasan-Razavi Province." *Journal of Applied Sciences* 8(23): 4455-4459.

Lehner, M. (2009). *Group Lending versus Individual Lending in Microfinance*. University of Munich, Governance and the Efficiency of Economic Systems.

Li, S., et al. (2013). "How Important are Endogenous peer effects in group lending? Estimating a static game of incomplete information." *Journal of Applied Econometrics*(28): 864-882.

Lv, D. (2010). "Deliberations on China's Rural Irrigation Construction, "Shensi Nongtian Shuili Jianshe de Fangxiang"." *Studies on Irrigation Development*, "Shuili Fazhan Yanjiu"(4).

Millar, A. and D. Navarick (1984). "Self-control and choice in humans: effects of video game playing as a positive reinforcer." *learning and motivation*(15): 203-218.

Mohan, R. (2006). "Agricultural Credit in India: Status, Issues and Future Agenda." *Economic and Political Weekly* 41(11): 18-24.

Nolan, P. (1976). "Collectivization in China: Some Comparisons with the USSR." *The Journal of Peasant Studies* 3(2): 192-220.

Ostrom, E. (2009). *Beyond Markets and States: Polycentric Governance of Complex Economic Systems*. Prize Lecture.

Park, A., et al. (1997). *Giving Credit Where Credit Is Due: The Changing Role of Rural Financial Institutions in China*. Working Paper No. 71, The William Davidson Institute.

Park, A. and C. Ren (2001). "Microfinance with Chinese Characteristics." *World Development* 29(1): 39-62.

Pary, C. E., et al. (2002). "Five years of Bt cotton in China-- the benefits continue." *The Plant Journal* 31(4): 423-430.

- Patnaik, U. (1987). "Three Communes and a Production Brigade: The Contract Responsibility System in China." *Social Scientist* 15(11/12).
- Pender, J. L. (1996). "Discount Rates and Credit markets: Theory and Evidence from Rural India." *Journal of Development Economics* 50(2): 257-296.
- Petrack, M. (2004). "Farm Investment, Credit Rationing, and Governmentally Promoted Credit Access in Poland: A Cross-Sectional Analysis." *Food Policy*(29): 275-294.
- Ratha, D. K. and A. Sarma (1992). "Price Subsidies and Irrigation Investment in India: Macro Implications." *Economic and Political Weekly* 27(39): A117-A121.
- Remenyi, J. (1991). *Where Credit is Due: Income-Generating Programmes for the Poor in Developing Countries*. London, Intermediate Technologies Publications.
- Roe, B. E. and D. R. Just (2009). "Internal and external validity in Economics research: tradeoffs between experiments, field experiments, natural experiments, and field data." *American Journal of Agricultural Economics* 91(5).
- Samuelson, P. (1964). "Principles of Efficiency: Discussion." *American Economic Review Proceedings* 54(93-96).
- Sinn, M. (2013). "Sequential Group Lending: A Mechanism to Raise the Repayment Rate in Microfinance." *Economica*(80): 326-344.
- Solnick, J., et al. (1980). "An experimental analysis of impulsivity and impulse control in humans." *learning and motivation*(11): 61-77.
- Srinivasaro, C., et al. (2014). "Long-term manuring and fertilizer effects on depletion of soil organic carbon stocks under pearl millet-cluster bean-castor rotation in western India." *Land Degradation and Development*(25).
- Stiglitz, J. E. (1990). "Peer monitoring and credit markets." *The World Bank Economic Review* 4(3): 351-366.
- Svedsen, M. and M. W. Rosegrant (1994). "Irrigation development in Southeast Asia beyond 2000: will the future be like the past?" *Water International* 19(1): 25-35.
- Thaler, R. H. (1981). "Some empirical evidence on dynamic inconsistency." *Economics Letters*(8): 201-207.
- Tilman, D. (1998). "The greening of the green revolution." *Nature* 396: 211-212.

Tsai, K. S. (2004). "Imperfect Substitutes: The Local Political Economy of Informal Finance and Microfinance in Rural China and India." *World Development* 32(9): 1487-1507.

Varian, H. R. (1990). "Monitoring Agents with Other Agents." *Journal of Institutional and Theoretical Economics*(146): 153-174.

Vickrey, W. (1964). "Principles of Efficiency: Discussion." *American Economic Review* LIV: 88-92.

Wang, J., et al. (2009). "The impact of climate change on China's agriculture." *Agricultural Economics* 40: 323-337.

Wolpin, M. R. R. a. K. I. (1993). "Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India." *Journal of Political Economy* 101(2): 223-244.

Wyck, B. (1999). "Can social cohesion be harnessed to repair market failures? Evidence from group lending in Guatemala." *Economic Journal*: 463-475.

Xu, Z. (2012). "The Chinese Agriculture Miracle Revisited." *Economic and Political Weekly* XLVII(14).

Table 2.1. IC Ratio by Province for the 1st, 6th, 11th years (continued onto next page)

	1979	1984	1989
Beijing	0.18	0.51	0.08
Tianjing	0.08	1.62	0.48
Hebei	0.10	1.96	5.77
Shanxi	0.07	2.26	2.83
Neimenggu	0.13	1.04	2.77
Liaoning	0.16	1.28	1.00
Jilin	0.10	4.00	3.86
Heilongjiang	0.08	1.65	2.91
Shanghai	0.18	0.43	0.07
Jiangsu	0.13	0.99	0.48
Zhejiang	0.15	1.55	2.84
Anhui	0.08	2.70	4.89
Fujian	0.11	1.32	1.61
Jiangxi	0.14	2.81	6.13
Shandong	0.09	0.93	0.78
Henan	0.10	3.01	6.22
Hubei	0.21	1.51	2.19
Hunan	0.18	3.19	5.00
Guangdong	0.16	2.35	2.04
Guangxi	0.18	1.87	4.00
Sichuan	0.30	8.07	11.20
Guizhou	0.34	2.98	5.79
Yunnan	0.28	6.89	7.22
Shannxi	0.12	2.41	9.01
Gansu	0.09	1.50	5.34

Qinhai	0.06	2.17	7.83
Ningxia	0.12	2.06	10.40
Xinjiang	0.12	2.16	5.40

Source: China Rural Finance Statistical Yearbook 1979-1989.

Table 2.2. Summary Statistics of Key Variables (continued onto next page)

Sample Statistics	Unit	Mean			Standard Deviation	
		1979	1984	1989	1979- 1989	
IC ratio (Individual versus collective loan)	N/A	0.14	2.33	4.22	2.13	2.54
Share of Effectively Irrigated Area in Total sown area	Percentage	32.06	33.48	33.87	33.38	15.54
Fertilizer use	Kilogram per hector	149.31	195.33	264.74	197.3	132.6
Real income per capita	RMB (at 1978 price level)	175.82	337.97	330.39	291.83	111.35
Inflation adjusted agricultural loan to individual households per capita	RMB (at 1978 price level)	21.37	47.66	53.49	40.97	46.54
Weather dummies						
<i>Humid regions</i>	N/A		0.39			0.49
<i>Half- humid regions</i>	N/A		0.14			0.35
<i>Regions covering both humid and half-humid areas</i>	N/A		0.21			0.41

<i>Regions</i>			
<i>covering both half-humid and half-drought areas</i>	N/A	0.07	0.26
<i>Regions</i>			
<i>covering both half-drought and drought areas</i>	N/A	0.18	0.38

Note: Number of observations in this table is 308.

Table 2.3. Sample Statistics by Income and Loan Quintiles

Quintiles	IC ratio		Share of effectively irrigated area in the total sown area		Fertilizer use (kilo per hectore)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Income (Lowest)	0.27	0.33	0.30	0.14	141.42	103.56
Income (Second)	2.51	2.8	0.28	0.11	201.99	140.99
Income (Third)	3.66	3.42	0.32	0.14	213.38	150.87
Income (Fourth)	2.87	2.05	0.37	0.21	179.15	121.77
Income (Highest)	1.25	1.31	0.40	0.14	252.12	119.50
Loan (Lowest)	0.5	0.71	0.37	0.15	184.42	136.31
Loan (Second)	1.49	1.95	0.35	0.14	176.40	131.99
Loan (Third)	3.2	3.19	0.33	0.19	194.30	109.08
Loan (Fourth)	3.3	2.98	0.30	0.12	225.41	125.31
Loan (Highest)	2.17	1.95	0.32	0.16	205.30	155.03

Source: Calculated by the author.

**Table 2.4. Regression Results for Level of Irrigation and Level of Fertilizer Use
(continued onto next page)**

Specification	Dependent Variables			
	Irrigation		Fertilizer	
	Basic	IV	Basic	IV
IC			0.43** (0.20)	0.59*** (0.19)
Income	-0.06 (0.04)	-0.03 (0.05)	0.18** (0.11)	0.15 (0.12)
IC*Income			-0.04 (0.03)	-0.08** (0.03)
Loan	0.00 (0.01)	0.00 (0.01)	-0.01 (0.03)	-0.01 (0.03)
IC*Loan			-0.02** (0.01)	-0.02 (0.01)
IC (-1)	-0.14* (0.07)	-0.14* (0.08)		
Income (-1)		-0.04 -0.05		0.09 (0.11)
Loan (-1)	0.00 (0.01)	0.00 (0.01)		
IC (-1)*Income	0.02 (0.01)	0.04 (0.03)		
IC (-1)*Loan	0.00 (0.01)	-0.00 (0.01)		
IC (-1)*Income (-1)		-0.02 (0.03)		

IC (-1)* Loan (-1)	0.00	0.00		
	(0.01)	(0.01)		
Climate controls	Y	Y	Y	Y
Year and provincial				
controls	Y	Y	Y	Y
R ² and Adjusted R ²	0.99	0.99	0.96	0.97

Source: Calculated by the author.

Table 2.5. Marginal Effects of lagged IC ratio on the level of irrigation

	Model 1	IV
IC (-1)	-0.02*** (0.01)	-0.02*** (0.01)
Income	-0.07 (0.05)	-0.04 (0.05)
Income (-1)		-0.04 (0.05)
Loan	0.00 (0.01)	0.00 (0.01)
Loan (-1)	0.00 (0.01)	0.00 (0.01)

Source: Calculated by the author.

Table 2.6. Marginal Effects of IC ratios on the Level of Fertilizer Use

	Model 2	IV	Model 3	IV
IC	0.1*** (0.02)	0.1*** (0.02)	0.06** (0.03)	0.06*** (0.03)
Income	0.19* (0.11)	0.14 (0.12)	0.17 (0.13)	0.19 (0.13)
Loan	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)
IC (-1)			0.04 (0.03)	0.04 (0.03)
Income (-1)				0.08 (0.13)
Loan (-1)			0.01 (0.03)	0.01 (0.03)

Source: Calculated by the author.

Table 2.7. Marginal Effects of lagged IC ratio on the growth rate of effective irrigated area

	Model 1	IV
IC (-1)	-0.00 (0.01)	-0.00 (0.01)
Income	-0.03 (0.04)	-0.02 (0.05)
Income (-1)	-0.01 (0.05)	-0.02 (0.05)
Loan	0.00 (0.01)	-0.01 (0.01)
Loan (-1)	-0.01 (0.01)	-0.01 (0.01)

Source: Calculated by the author.

Figure 2.1. Scatterplot of the Irrigation and IC

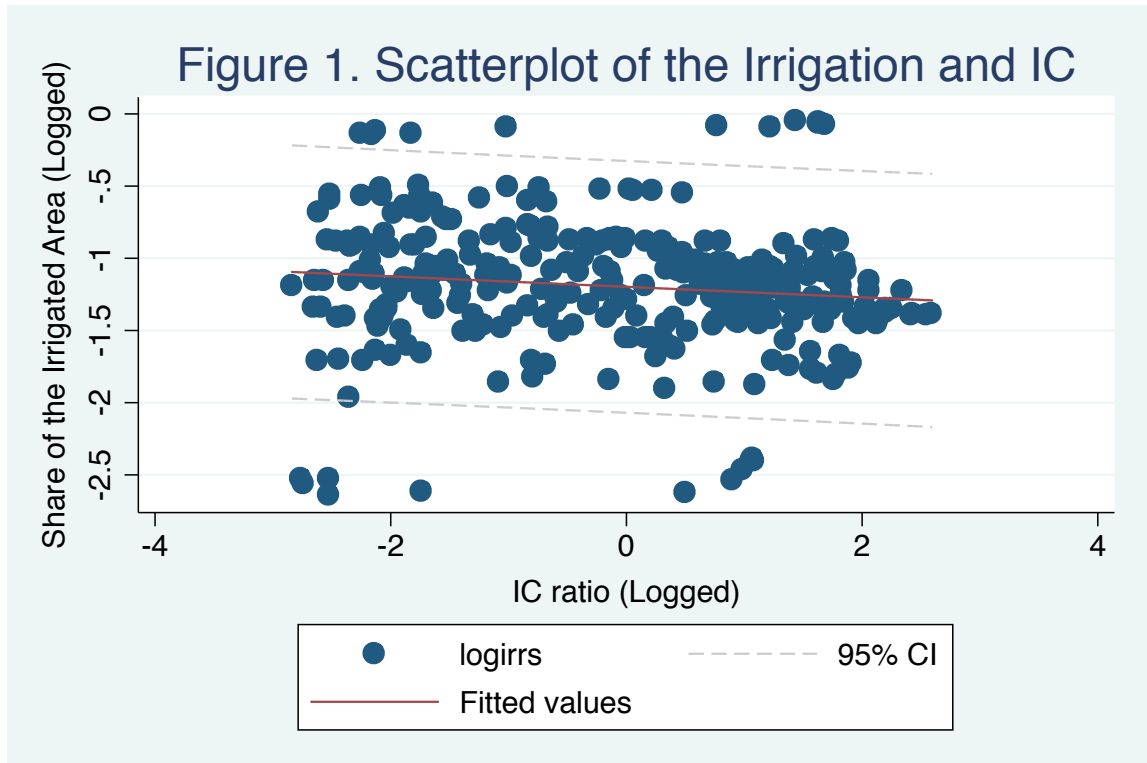
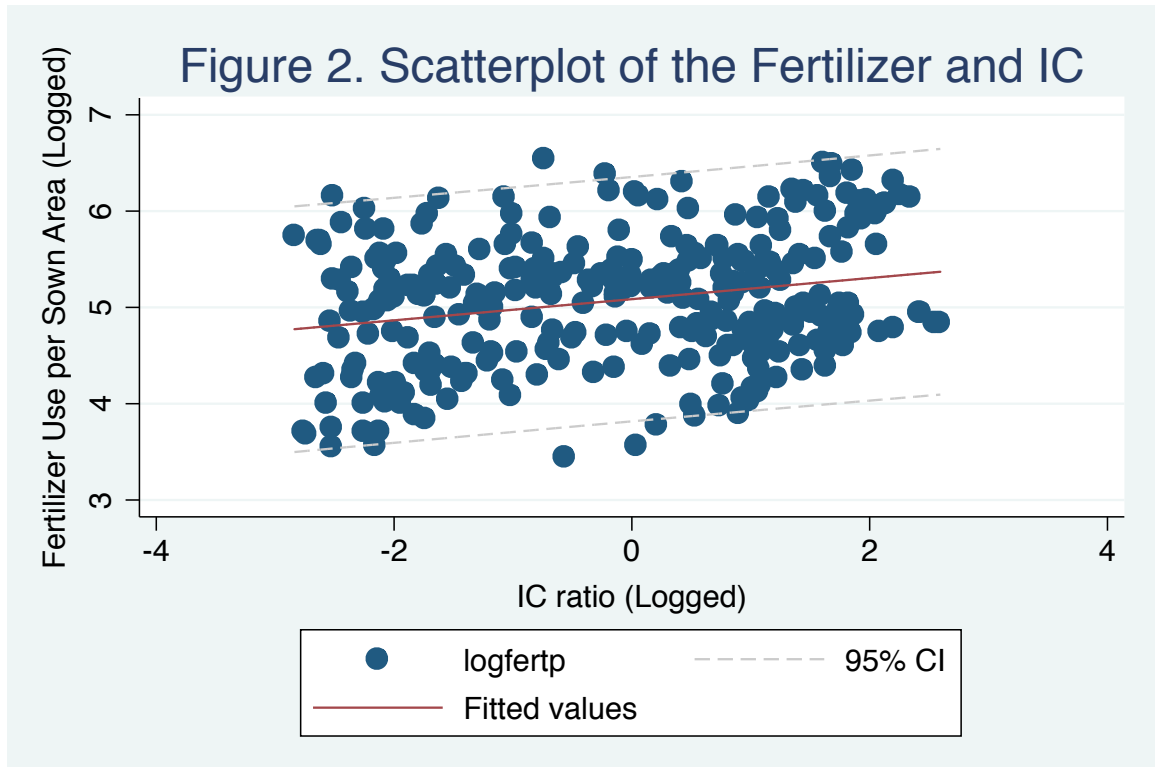


Figure 2.2. Scatterplot of the Fertilizer and IC



CHAPTER 3

RENEWABLE ENERGY INVESTMENT AND EMPLOYMENT IN CHINA

3.1 Introduction

In this paper, I estimate the impact on employment creation through investments in three renewable energy sectors in China, i.e. solar, wind and bioenergy. I also make comparable estimates for China's traditional fossil fuel sectors, i.e. coal, oil and natural gas.

The underlying issue at hand motivating this research question is the massive global challenge to dramatically reduce greenhouse gas emissions and thereby control climate change. According to the Intergovernmental Panel on Climate Change (IPCC), the leading global authority on this question, global emission will need to fall by 39 percent from 2010 levels by 2030 and 72 percent by 2050, in order for there to be a decent prospect to achieve climate stabilization (IPCC 2014).

At present, China is one of the two leading countries in terms of both energy consumption and CO₂ emissions. Together, China and the U.S. account for nearly 39% percent of world energy consumption. Their respective levels of energy consumption were nearly identical in 2010, with China at 100.9 quadrillion BTUs (Q-BTUs) and the U.S. at 98 Q-BTUs. In terms of carbon emissions, China is at a higher level, at 7,997 million metric tons (mmt), while the U.S. is at 5,637 mmt. Together, they account for 43 percent of all global carbon emissions. Obviously we must give major attention to developments in China, along with the United States, in terms of mounting an overall project for controlling climate change.

The climate change has huge impacts on China's domestic environment in terms of water shortage, air pollution and soil degradation. At present, the average northern Chinese has access to less than a fifth of the supply of usable water that is above the international threshold for water stress—the stress level being 1,000 cubic meters of usable water per person per year.⁸⁸ Cities in China's Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei region suffer over 100 haze days every year, with PM2.5 (particles with an aerodynamic diameter less than 2.5 micrometer) concentration two to four times above the World Health Organization guidelines.⁸⁹ Moreover, one-fifth of China's arable land is contaminated with heavy metals, making the land scarcity issue even worse.⁹⁰

Further, at the beginning of 2013, the Health Effects Institute announced that outdoor air pollution contributed to 1.2 million premature deaths in China in 2010 alone, which is nearly 40 percent of the global total. Preliminary estimates suggest that about 11 percent of cases of cancer of the digestive system may be attributable to polluted drinking water in China.⁹¹ Drinking water for roughly 190 million of the rural population contains harmful substances that exceed health standards. Regarding food security issues, it is estimated that extreme drought could more than triple crop losses in northeast China to 13.8 million metric tons, or 12 percent of the total production, by 2030.⁹² Moreover,

⁸⁸ The Economist (2013): Desperate Measures. Published on Oct 12th 2013 at <http://www.economist.com/news/leaders/21587789-desperate-measures>, retrieved on October 23, 2014.

⁸⁹ Greenpeace (2012): Dangerous Breathing—PM2.5: Measuring the human health and economic impacts on China's largest cities.

⁹⁰ Josh China and Brian Spegele, China's Details Vast Extent of Soil Pollution. *The Wall Street Journal*, published on April 17th, 2014 at <http://online.wsj.com/articles/SB10001424052702304626304579507040557046288>, retrieved on October 23, 2014.

⁹¹ See China Water Risk (2010): China's Water Crisis Part I.

⁹² McKinsey & Company, From Bread Basket to Dust Bowl, November 2009

today, pollution has replaced land disputes as the main cause of social unrest in China.⁹³

During the 11th Five-Year Plan period (2006-2010) there were over 300,000 environmental complaints and this number has been growing at an average annual rate of 29 percent since 1996.^{94,95}

All these environmental issues are translating into unsustainable elements in China's current growth model. In response to the growing domestic and global focus on the issue of climate change, the Chinese government is making efforts to substantially reduce emissions.⁹⁶ If China can succeed in reducing CO₂ emission from energy-based sources, this will also significantly alleviate the related crises with respect to air pollution, water shortage and soil contamination.

In 2011, the Chinese government set as a target the reduction of the country's level of carbon intensity—i.e. its carbon dioxide emission per unit of GDP—by 17 percent from 2010 to 2015.⁹⁷ In fact, as of 2013, this number has already fallen by about 20 percent compared with five years ago and the government is aiming to cut it further.⁹⁸ In 2011, the government aimed at increasing the non-fossil-fuel share of total primary energy by 11.4 percent by 2015—the target was then quickly revised upward to a more

⁹³ Bloomberg News, Chinese Anger Over Pollution Becomes Main Cause of Social Unrest. Published on March 6th, 2013 at <http://www.bloomberg.com/news/2013-03-06/pollution-passes-land-grievances-as-main-spark-of-china-protests.html>, retrieved on October 23, 2014.

⁹⁴ Figures from the China's Ministry of Environmental Protection (MEP)

⁹⁵ Announcement made by Yang Zhaofei, vice-chair of the Chinese Society for Environmental Sciences in 2012.

⁹⁶ Osnos 2009, Green Giant. The New Yorker, December 21st, 2009.

⁹⁷ See No.41 State Council document on controlling the emission of greenhouse gas in 2011.

⁹⁸ The East is Grey, *The Economist*. Published on Aug 10th, 2013, at <http://www.economist.com/news/briefing/21583245-china-worlds-worst-polluter-largest-investor-green-energy-its-rise-will-have>, retrieved on October 23, 2014.

ambitious one: 20 percent of its energy from renewable energy sources by 2020, the same target as in richer Europe.⁹⁹

In 2012, China has reclaimed its top position from the United States in terms of renewable energy investments, totaling \$65 billion, 20 percent more than in 2011 and constituting 30 percent of all renewable energy investment from G-20 countries. In 2013, China invested more in renewable energy than the whole of Europe (Bloomberg New Energy Finance 2014).

China's big push on investing in renewable energy since 2007 implies a promising future of a greener economy in China. However, one of the concerns for building a renewable-based economy is the likelihood that a significant contraction of production within China's traditional energy sectors—i.e. coal, oil and natural gas—will lead to major employment losses in these traditional fossil fuel sectors. Such employment losses could potentially trigger further economic instability in a populous country like China. How to implement this structural change while guaranteeing a smooth transition in employment is thus highly relevant in discussing the feasibility of the renewable energy plan in case of China.

The potential trade-off between environmental protection and employment stability has been a concern in the literature regarding the economic impacts of substituting fossil fuel energy with renewable energy (Rose and Wei 2006; Lehr et.al 2008; Moreno and Lopez 2008; Alvarez et. al 2009; Frondel et.al 2009; Pollin et. al 2009; Ragwitz et.al 2009; Mitchell 2011; Pollin et. al 2014).¹⁰⁰ However, in the case of China, the

⁹⁹ See 2011-2015 Five Year Plan. Also see The East is Grey, *The Economist*. Published on Aug 10th, 2013, at <http://www.economist.com/news/briefing/21583245-china-worlds-worst-polluter-largest-investor-green-energy-its-rise-will-have>, retrieved on October 23, 2014.

¹⁰⁰ See also Atkin 2014. How Obama's Climate Rule Could Change The U.S. Job Market. Posted online on June 6, 2014 at ThinkProgress. <http://thinkprogress.org/climate/2014/06/06/3444200/clean-energy-epa->

employment issue has not been adequately addressed. To date, there are no reliable estimates of the employment impacts of renewable energy investments in China.

This essay addresses the employment issue through estimating the relative employment impacts of renewable energy investments versus spending within the traditional fossil fuel sectors. My estimates are based on input-output modeling with China-specific data of sectorial and sub-sectorial weighting techniques within China's input-output (I-O) model. This paper aims to make a contribution to the research literature in several ways. First, it is focused on the unique labor market structure of China. Second, working with China-specific data, it estimates the job creation in the renewable energy sectors as well as the traditional fossil fuel sectors, providing empirical evidence relevant to the feasibility of a transformation in China to a clean-energy based economy. Third, this study, examines employment generation in terms of formal and informal jobs within China. This enables us to also consider the issue of the quality of jobs being generated by clean energy investments, as opposed to focusing only on the quantity of jobs.

I find that spending within three segments of the renewable energy sectors—solar, wind and bioenergy—will, in combination, produce about *twice as many jobs per dollar of expenditure than an equal amount of spending on fossil fuels*. This demonstrates that there need not be any significant tradeoff in China between environmental protection and expanding job opportunities in a transition to a renewable-based economy.

rule/. See also Dickerson 2014. EPA rules draw wide criticism in W.Va, posted online on June 2nd, 2014 at The West Virginia Record. <http://wvrecord.com/news/267555-epa-rules-draw-wide-criticism-in-w-va>. Retrieved on September 6, 2014.

With respect to job quality concerns, I also find that more than 70 percent of jobs generated by renewable energy investments are created in China's informal economy. Informal economy jobs in China, as elsewhere, are characterized by lower pay, and a lack of benefits and basic protections for workers. The high proportion of informal jobs generated by renewable energy investments in China thus does raise major concerns about these new job opportunities. At the same time, I also find that the proportion of informal sector jobs in China's coal, oil and natural gas sectors are roughly equivalent to the proportions of informal jobs in renewable energy. Thus, considering both quantity and quality of job issues, the results of my estimates demonstrate that, for the case of China, the project of building a clean energy economy does not face the prospect of a massive obstacle in terms of negative employment effects.

The remaining sections of the paper are organized as follows. In section 2, I present a brief overview of the existing literature regarding estimates of employment generation through investing in renewable energy sectors in China. My critical review suggests that to date, there are no reliable estimates of the employment impacts of renewable energy investments in China, or any relative employment effects of renewable energy investments versus spending within the traditional fossil fuel sectors. In section 3, I introduce the input-output model. I also discuss the advantage and limitation of this methodology through comparing it with alternative approaches. In section 4, I discuss the data sources and data construction methods used for estimation. Specifically, I discuss the input-output data, employment data decomposed into formal and informal sector, as well as the cost breakdown of both renewable energy and fossil fuel sectors in China. In section 5, I present the main results from my estimation exercises. These results include

figures for employment generation per \$1 million in solar, wind, bioenergy, coal, and oil and gas sectors—i.e. the “employment-output ratios” for each of China’s energy sectors. I also specify the composition of the employment in terms of formal and informal jobs, as well as direct and indirect jobs. The indirect jobs here refer to the jobs created by purchases from the supplies of the renewable energy sectors. Moreover, I present the projection for total employment generation from the renewable energy sectors by 2015, 2020, 2030 and 2050. Section 6 concludes the paper.

3.2 Literature Review

One of the strongest obstacles to a successful transition to a green economy is the consequential job loss that will occur as in economy’s fossil fuel sectors (Mitchell 2011).¹⁰¹ If job loss in the fossil fuel sectors outweighs those generated in the renewable energy sectors, then the economy will suffer an overall decline in its employment level. Therefore to some analysts, building a green economy poses a severe trade-off between environmental protection and employment stability (Rose and Wei 2006; Alvarez et. al 2009; Frondel et.al 2009). This issue has become especially sensitive after the recent economic crisis as the USA and many European countries are experiencing economic stagnation with high unemployment level. Yet a growing body of literature has examined the employment generation of investing in renewable energy, arguing that these investments in general generate higher employment-output ratios in an economy’s energy

¹⁰¹ See also Atkin 2014. How Obama’s Climate Rule Could Change The U.S. Job Market. Posted online on June 6, 2014 at ThinkProgress. <http://thinkprogress.org/climate/2014/06/06/3444200/clean-energy-epa-rule/>. See also Dickerson 2014. EPA rules draw wide criticism in W.Va, posted online on June 2nd, 2014 at The West Virginia Record. <http://wvrecord.com/news/267555-epa-rules-draw-wide-criticism-in-w-va>. Retrieved on September 6, 2014.

sector activities than the fossil fuel sectors (Lehr et.al 2008; Moreno and Lopez 2008; Pollin et. al 2009; Ragwitz et.al 2009; Wei et. al 2010; Strietska-Ilina et.al 2011; Pollin et. al 2014).¹⁰² As a result, the employment level as a whole will not decline.

The employment impacts of investing in renewable energy are highly relevant to the discussion on the feasibility of a green economy plan in China. Although using renewable energy to substitute for traditional energy is critical for China to combat environmental pollution and greenhouse gas emissions in particular, it is also crucial to examine whether a significant reduction in production from traditional energy sectors will induce employment losses, especially since employment issues could potentially trigger severe economic instability in a populous country like China.

The existing literature has never treated employment impacts of investing in renewable energy in China as a primary concern. Existing estimates either lack a transparent methodological discussion or do not provide a clear definition of employment as a concept. They are therefore incapable of serving as a solid empirical evidence for policy discussions on building clean energy economies. Most employment estimates appear in the official documents or think tanks affiliated to the government, mainly as a justification for the big push on renewable energy development. But even these have stopped appearing in the literature since 2012, exactly when the renewable energy investment plan began being implemented. It is therefore not surprising to see a shortage of serious studies on this topic, especially from the Chinese-language studies.

¹⁰² See also Union of Concerned Scientists: Benefits of Renewable Energy Use. http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/public-benefits-of-renewable.html#jobs

Table 3.1 summarizes the employment estimates of renewable energy investments in China from the recent literature. Specifically, I organize the literature as follows. Column 1 presents the methodology used in these studies. Column 2 examines whether they have specified the various kinds of renewable energy technologies in their employment estimates. Column 3 examines whether employment estimates are specified as formal or informal employment. Here the formal employment refers to those jobs with regular working hours and benefits and are protected under state labor laws. By contrast, informal employment refers to jobs outside the formal economy, with low pay, little job security, few or no benefits, and no legal protection. The specification between formal and informal employment is crucial because although they can be treated equivalently in the quantitative sense, one job in the informal economy implies significantly lower job quality relative to one created in the formal sector.¹⁰³ Column 4 examines whether employment estimates are identified as direct or indirect jobs. Direct jobs refer to the core activities in the energy sectors whereas indirect jobs refer to those jobs generated through the supply chains associated with renewable energy production. Distinguishing direct and indirect jobs helps to specify the composition of the employment opportunities in the renewable energy sectors. Column 5 presents information on the relative spending level for the employment estimates available in the examined studies. Column 6 categorizes the employment estimates in terms of stocks or flows and the last column shows the employment estimates.

A brief overview of the table shows a wide range of estimates over various time spans with no consistent methodology or definition for any systematic comparison. In

¹⁰³ More detailed discussion on formal and informal employment in China is in Section 4.2 through 4.5. Data construction for the formal and informal employment is presented in Section 4.3 and 4.5.

terms of the methodology, almost half the studies do not specify their estimation base (CREIA 2009; China's 12th Five Year Plan 2011; CCICED 2011; NDRC 2012).¹⁰⁴ Some studies resort to qualitative methods such as interviews or literature surveys (UNEP et.al 2008; IRENA 2011; REN21 2013). Only two studies discuss the quantitative methods they use and the relevant assumptions (CASS 2010; Greenpeace 2012). CASS (2010) uses the Input-Output model (I-O) at a very aggregated level. Multipliers are calculated for the interactions among only three sectors: agricultural, industrial and service sector (p 86-7). An I-O model could provide detailed information on the interactions among various sectors, and therefore allow estimation of employment from the relevant sectors. However, information on only three sectors is too general to even distinguish the composition of various different renewable sectors. Therefore the estimation results will not be the most reliable.

The calculations by Greenpeace (2012) are based on the assumptions that “for every new megawatt of capacity installed in a country in a given year, 14 person/years of employment is created through manufacturing, component supply, wind farm development, construction, and transportation” and “0.33 person/years” necessary “for operations and maintenance work at existing wind farms”, which “seems to work as a global average” according to Greenpeace (2012). A key disadvantage of these assumptions is that they treat various renewable energy sectors within and among countries as having the same employment-output ratios. Although this might be useful as a first approximation for a global estimate, they are incapable by nature to estimate the

¹⁰⁴ Keith Bradsher “China is leading the race to make renewable energy”, The New York Times, published Jan 30, 2010. http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html?pagewanted=all&_r=0, Accessed in November 3rd 2013.

employment-output ratios for individual renewable energy sectors, and for specific countries.

Most studies in this literature survey have specified the employment generation among wind, solar, and bioenergy sectors. However, it is still impossible to make comparisons among these estimates, as some of the studies focus only on one sector of their interest (Greenpeace 2012; NDRC 2012), yet other produce estimates for a combination of the three sectors as a whole (UNEP et.al 2008; REN21 2013). Some studies do not even specify the kind of renewable energy sectors they are estimating (CREIA 2009; CCICED 2011). For example, CCICED (2011) estimated that China would generate 10.58 million jobs in the green sector between 2011 and 2015 while losing 952,100 jobs in high polluting and energy-intensive industries.¹⁰⁵ Yet these employment estimates are for the “green sector” in general, including not only the renewable energy sectors examined in this paper, but also all the other sectors such as the waste management sector that contributes to a green economy. This information on the total employment of the generally defined “green sector” is thus of little value in understanding employment-output ratio of individual renewable energy sectors.

Regarding the definition of employment, not a single study in this literature survey discusses its employment estimates for the Chinese case in terms of formal and informal employment categorizing. Only two studies (CASS 2010; REN21 2013) specify the

¹⁰⁵ Li Jing “Green industries to add millions of jobs,” China Daily, Nov 16th 2011. http://www.chinadaily.com.cn/china/2011-11/16/content_14101445.htm, accessed in Nov 3rd 2013. In this essay, I mainly refer to the 12th Five Year Plan for comparison because no clear-cut renewable energy target has become available in the 13th Five Year Plan (2016-2020) by the time this paper is written. See discussion on solar energy development in the 13th FYP at <http://www.lsxxy-edu.com/html/xuexiaoxinwen/429.Html>, published on August 24th, 2014 and retrieved on October 2, 2014. Also see talk by the Director of the National Energy Bureau regarding wind energy development in the 13th FYP at <http://finance.sina.com.cn/energy/news/20140821/150520080922.shtml>, published on August 21st, 2014 and retrieved on October 2, 2014.

employment estimates with regard to direct or indirect jobs, despite a slight difference in the definition used in this paper.¹⁰⁶ CASS (2010) estimated that about 567,000 direct jobs and 1.52 million indirect jobs could be generated in the energy-saving and environment-related sectors. REN21 (2013) estimated that, from 2009 to 2012, 267,000 people were working in the wind sector, 300,000 in the solar PV industry, 1.1 million in the solar power industry, and 380,000 in the biomass sector.

Almost half the studies do not specify the spending level with respect to the employment estimates. CASS (2010) suggested that among the four trillion RMB stimulus-package issued by the Chinese government during the financial crisis, about 580 billion RMB (or 14.5 percent) was directly related to ecological infrastructure. NDRC (2012) shares the same investment estimates with China's 12th Five Year Plan that total renewable energy investment between 2011-2015 amounts to 1.8 trillion RMB. However, in most cases, an investment amount was not estimated relative to specific renewable energy sector. It is therefore difficult to estimate how much employment is generated relative to certain spending level for each renewable energy sector. Finally, the use of stocks or flows for employment estimation is also inconsistent among the existing literature, making it hard to undertake direct comparisons.

In general, the existing literature has not provided any serious estimates for employment generation through renewable energy investment in China. More specifically, the literature does not provide either a clear methodology for estimation or even a clear concept of the term "employment." It is therefore reasonable to conclude that, to date, there are no reliable estimates of the employment impacts of renewable

¹⁰⁶ Note that definition of direct and indirect jobs in REN21 (2013) is slightly different from this paper whereas the former does not include R&D jobs as direct jobs.

energy investments in China, or any relative employment effects of renewable energy investments versus spending within the traditional fossil fuel sectors.

3.3 Methodology

3.3.1 Input-output model

This paper mainly builds on the Input-Output (I-O) model adopted in studying the United States case in Pollin et.al (2009) to estimate the employment impacts of renewable energy investment in China. A typical I-O model records detailed information on the supply and demand relationships between various industrial sectors and distinct categories of final demand in the economy.¹⁰⁷ The I-O model is as follows:

$$X_i = a_{i1}X_1 + a_{i2}X_2 + \dots + a_{ij}X_j + D_i \quad (1)$$

$$X = AX + D \quad (2)$$

$$(I - A)X = D \quad (3)$$

$$X = (I - A)^{-1}D \quad (4)$$

In the first equation, X_i indicates the output produced by the i th sector; a_{i1} indicates the required input from the i th sector to produce output for the j th sector. Equation (2) contains the same information as in equation (2), only is written in the vector form, where notation A indicates an i by j matrix containing all elements of a_{i1} through a_{ij} . Equation (3) is a re-writing of equation (2) where notation I indicates an identity matrix. Equation

¹⁰⁷ The I-O model is based on aggregate identities where the total output for any sector is assumed to be fully consumed by two channels: one is directly consumed by final users (i.e. household consumption, investment, government expenditure and exports; the other is consumed as inputs by other sectors for output production.

(4) expresses X in terms of all the other components in the equation with the assumption that $(I-A)$ is invertible.

The I-O model shows how much materials (input) from each sector in the economy are used up by economic sector X to produce the goods and services (output) for the consumption of households, private businesses investment, government expenditures, and exports. Information on imports is also included, often implicitly, in the I-O model, through the documentation of “leakages.” It follows that the more detailed breakdown of economic sectors in an I-O model (e.g., rice farming sector versus agricultural sector in general), the more precise the inter-sectorial information and hence the employment estimation based on it. An example illustrates how an I-O model tracks the change in all the economic sectors caused by an initial increase in final demand. An increase in purchases of smart phones will cause purchases of intermediate inputs to rise (e.g., electronic components). Higher demand for electronic components will, in turn, increase demand for the inputs used by the electronic components industry (e.g., steel or plastics), and so forth. Given this information from the I-O model, we can estimate that following an investment (one element of the final demand) increase in, say, the solar energy industry, how the relevant sectors such as those manufacturing solar panels, and those producing steels or plastics for the manufacturing of solar panels, respond to the change.

One challenge in using an I-O model to estimate how the increase in spending in certain renewable energy sectors affects the whole economy is that these renewable energy sector activities are not as yet specified into distinct industrial sectors, such as “solar energy sector” or “wind energy sector.” To solve this issue, I use information on the cost components of such investment from the existing literature and then use the

existing sectors within the I-O model to construct a new renewable energy sector based on the weighting structure that reflects such cost composition. The first step in the estimation is to calculate the output/investment ratio (O/I ratio), meaning how much change in output will be induced by a change in the investment level, as is discussed above.¹⁰⁸ The second step is to calculate the employment/ output ratio (E/O ratio), which indicates how much employment is required to produce a certain output level of renewable energy goods. Assuming a linear model, the multiplication result of the row vector E/O and the matrix O/I implies the E/I ratio, suggests the total employment generation from investment in the renewable energy goods.

3.3.2 Methodological concerns

The assumption of a linear I-O model creates some limitations that need to be addressed. To put it into the context of this paper, linearity here suggests that the employment impacts of a \$1 billion renewable energy investment project will be exactly 1000 times greater than a \$1 million spending on the same project. However, this assumption might not be able to generate the most accurate estimates in some situations.

First, the basic linear I-O model does not incorporate any supply constraints that might occur from investing, for example, 1,000 times more in the same project. Yet within the current context of the Chinese economy, which is operating with substantial overcapacity especially after the 2008 global economic recession, it is reasonable to assume that supply constraints are less binding than demand constraints in the short and intermediate term.

¹⁰⁸ This O/I ratio corresponds to the Leontief inverse coefficient, generated through matrix manipulation on the raw I/O data.

Second, the basic linear I-O model also assumes that relative prices are fixed regardless of any changes in demand. For example, if demand for solar panels declines due to the economic recession, then prices of the panel will fall. This could provide incentives for purchasing more solar panels therefore raise the demand again. This issue could be addressed in a more fully specified model such as in Computable General Equilibrium (CGE) model yet with its own limitation as discussed later.

Third, when applying basic linear I-O model, productive relationships are assumed to be stable over the period of analysis. This assumption would seem especially relevant in employment estimation of the renewable energy investment. However, when put into the context, it only implies that productive relationships such as those between the manufacturing sector and construction sector in building solar energy are fairly stable, which is realistic to a certain extent. In Section 5.4, I compare the output-investment ratio I-O tables from 1995 to 2011 to show that productive relationship among sectors could be realistically assumed to be fairly stable in the context of China.

Fourth, the static I-O model does not incorporate the treatment of time dimension either. It is certainly realistic to think that investment and employment generation occurs over a reasonable amount of time period rather than happening at one fixed point in time. A dynamic model would address this concern more accurately yet it is not necessary for this paper since the estimates cover an intermediate term rather than a specific year.

The advantage of a relatively simple and transparent I-O approach is seen more clearly by comparing it with the Computable General Equilibrium (CGE) model, which is a relatively more complex modeling framework. In the CGE models, price dynamics, supply constraints and technological change are incorporated into the basic I-O structure

through assumptions on a variety of price elasticities and equilibrium conditions. Critically, most CGE models operate with an assumption of full-employment. Despite the crucial roles these assumptions play in the model, they are almost impossible to be identified. In addition, these models are usually proprietary. This proprietary nature generally presents independent verification of the logic of the model. Also, the assumption that the economy operates at full employment at all times is unrealistic and inherently contrary to the purpose of using the model, which is to estimate the number of job creation through investments. Compared with the CGE model, the I-O model has critical benefits in terms of its relative simplicity, clarity, minimum number of behavioral assumptions and ability to handle details more fully as a result.

In general, a basic linear I-O model is still the most effective available tool for estimating the employment effects of a large-scale renewable energy investment project in a national economy.

3.4 Data Construction and Discussion

3.4.1 Input-output data

Starting from 1987, the Chinese Statistics Bureau published the Input-Output Table of China every five years, with the most recent one in 2007.¹⁰⁹ This 2007 I-O table is the most detailed table since 1987, providing information on the 135-industry level basis.¹¹⁰ A more recent I-O table, if available, would be preferable for more accurate prediction of

¹⁰⁹ Unfortunately the 2012 I-O table that was supposed to be published one year ago has not come out yet by the time this paper is written.

¹¹⁰ The 135 sectors include five agricultural sectors; five mining sectors; 81 manufacturing sectors; three utilities sectors; one construction sector; nine transportation, storage and postal services sectors; three communication sectors, one retail sector, two hotel and restaurant sector, two finance sectors, one housing sector, and 22 other services sectors.

employment generation. However, this more recent I-O table is not yet available.¹¹¹ A 2010 I-O table is available at 54-sector, yet I choose the 2007 I-O table for its details that are most critical for the estimation. Data limitation issue will be addressed and compensated by discussion of productivity change in section 5.5.

3.4.2 Importance of separating the formal and the informal sector employment

There are three main reasons to separate the formal and informal sectors in the discussion of employment impacts of investing in renewable energy.

First, employment opportunities within the formal economy differ significantly from those in the informal economy in terms of job quality, even in the same industrial sector. If jobs generated in the formal and informal sectors are treated as equivalents, it implies that large numbers of jobs can be seen as an adequate substitute for low quality jobs.

In 2012, about 75 percent employees within the urban informal economy come from rural migrant workers (*nongmin gong*) working in the cities.¹¹² In 2013, 35 percent (or 58 million) of the 166 million rural migrant workers work in the manufacturing and another 23.5 percent (or 39 million) in construction, making for a total of about 97 million working in the urban “secondary industry.” The remaining 69 million rural migrant

¹¹¹ From regional statistics institution such as that in Shanghai, I found the national schedule for compiling and publishing I-O statistics. The regional data are expected to be submitted to the National Statistics Bureau around August 2013, and the national statistics is expected to be published after 2014. However, it is still not published by the time this paper is written. See <http://tjj.stats-sh.gov.cn/trcc/index.asp>

¹¹² Rural migrant workers are defined as those with “agricultural status” according to the household registration, but live on non-agricultural activities or migrate to other places for work for more than 6 months. In 2014, National Bureau of Statistics published the data on rural migrant workers covering 2008 to 2013 period. 163.3 million indicate the number of rural workers who literally “migrate” to places other than their local geographical areas such as towns that belong to the same administration as their rural origin, and the ratio is based on its share of the total 218.6 million working in the urban informal sector in 2012. See *National report on rural migrant workers in 2013*, published on May 12th, 2013 and retrieved on October 5, 2014. See http://www.stats.gov.cn/tjsj/zxfb/201405/t20140512_551585.html. The 2007 data on rural migrant workers is not available, yet Huang (2009) reported the ratio for 2006 as about 72 percent, or 120 million rural migrant workers over 168.2 million urban informal economy.

workers are working in the “tertiary industry” (or the service sector).¹¹³ This pattern did not change significantly since 2006 (Huang 2009).¹¹⁴ These are the workers “who have no security of employment, receive few or no benefits, and are often unprotected by labor laws” (Huang 2009).

In addition to the rural migrant workers, the remaining quarter of the urban informal economy consists of urban residents who are laid off (*xiagang*) from their previous state-owned or collective enterprises and who are now working mainly in the tertiary industry of services (Huang 2009).

Table 3.2 shows the average annual wage comparison between the urban unit employees (or the formal sector employees) and the rural migrant workers who constitute the majority of the urban informal economy. As we can see, the wage for the rural migrant workers are no more than just 60 percent of the pay received by regular urban labors, and this pattern has not changed at all since 2004.¹¹⁵ On the other hand, 84 percent of the rural migrant workers are still working more than 44 hours a week in 2013.¹¹⁶ Despite the low pay yet extra work time, these rural migrant workers enjoy little job security. In 2013, fewer than half of them are working with some kind of a contract, among which only 23 percent have contracts that are over one year.¹¹⁷ Moreover, only 17.6 percent of the group had medical insurance and 15.7 percent of them had retirement

¹¹³ According to Huang (2009), these people work as domestic helps, guards of residential compounds, barber shop and massage parlor personnel, delivery persons, garbage collectors, street cleaners, or run small shops, stalls and vendors.

¹¹⁴ See *Report on China's rural sector 2007: new development, new issues and new challenges* published on April 2nd 2008. Retrieved on October 5, 2014 at http://www.china.com.cn/aboutchina/zhuanti/08zgshxs/2008-04/02/content_14114764.htm.

¹¹⁵ See discussion on 2004 data in Huang (2009).

¹¹⁶ See *National report on rural migrant workers in 2013*, published on May 12th, 2013 and retrieved on October 5, 2014. See http://www.stats.gov.cn/tjsj/zxfb/201405/t20140512_551585.html.

¹¹⁷ Ibid.

benefits in 2013.¹¹⁸ Although there is another 25 percent of the urban informal economy not represented by the rural migrant workers, it is reasonable to assume that the work and living situation of those workers would not be significantly better than the rural migrant workers due to the strong reserve army effects.

Second, focus on the formal sector employment will leave out the entire employment population in the rural sector, which constitutes the preponderance of employment generated by investing in bioenergy. Therefore leaving out the agricultural employment will give an underestimation of the actual employment.

Third, it is important to note the possibility that a rise in final demand might not increase employment in the informal economy as much as in the formal economy. This is especially relevant to those self-employed who would work more to address the rising demand instead of hiring more employees. It could also apply to others working in the informal economy that are underemployed to some extent and would be willing to work more hours to receive higher earnings instead of having their employers hire another worker. This is to say, using a national I-O model, it is not able to tell how the increase in total earnings, as a result of a boost in final demand will 1) increasing the number of self-employed jobs at the prevailing earnings level; 2) increasing earnings while keeping the level of employment constant, or 3) some combination of the first two possibilities (Pollin et.al 2014a). Therefore, a separation of formal and informal sector employment will give a clearer picture for the job creation that are certain to be generated through investment (i.e. those in the formal sector), as compared to the employment generation

¹¹⁸ Ibid.

that might be overestimated (i.e. those in the informal sector). This issue is especially relevant for the bioenergy sector (see more discussion in Section 5.2).

3.4.3 Employment data: formal sector employment

The 2007 employment data are compiled from Table 3-1 in the 2008 China Labor Statistical Yearbook on a 90-industry level basis. The only employment data available at this level of detail are for the urban unit employment (*danwei jiuye ren yuan*, a concept different from urban employment, *chengzhen jiuye ren yuan*, as will be explained below).¹¹⁹ Two major groups of population are excluded from the statistical definition of urban unit employment: first, the entire employment population in the rural sector, which was about 62 percent of the total national employment in 2007 and 52 percent in 2012; second, those working in the urban sector but in the private enterprises, or as self-employed or simply unregistered in the national statistics.¹²⁰ This population was 22 percent or 28 percent of the entire employment population across for year 2007 or 2012 respectively.¹²¹

Compared to urban employment data, urban unit employment data are more strictly defined in the sense that they only include employment in three types of officially registered enterprises, or units (*danwei*). They are the state-owned units (i.e. including the “state-owned” enterprises and the “state-holding” enterprises), urban collectively-owned units, and other ownership units (i.e. mixed ownership, or enterprises funded by foreign

¹¹⁹ Note that according to the statistical definition available from the China Bureau of Statistics, those who work in the Township and Village Enterprises (TVEs, *xiangzhen qiye*) are counted as rural employment, therefore not included in urban employment from Table 3-1. The urban and rural division here is in the administrative sense, unrelated to the household registration status of the worker.

¹²⁰ The percentage estimation is calculated based on Table 1-1 from the 2008 and 2013 China Labor Statistical Yearbook.

¹²¹ Ibid.

investment, or by investments from Hong Kong, Macau, and Taiwan).¹²² This type of employment is often associated with regular wage, normal working hours, standard benefits and job security, thus providing the best available estimates for urban formal sector employment in China.

Table 3.3 presents the relationships among these statistical concepts for years 2007 and 2012. As is shown, the urban unit employment (or formal sector employment), which aggregates employment from the three types of units, represents about 41 percent of total urban employment, and this percentage does not change significantly from the 2007 data used in this paper to the latest available employment data in 2012.

3.4.4 Employment data: informal sector employment

Table 3.3 also shows that the share of urban informal employment as of total urban employment (about 59 percent) is relatively stable from 2007 to 2012. The informal employment includes urban private enterprises and self-employment, as well as other urban employment that is not formally counted in the national statistics.

The concept of private enterprises here does not imply all nongovernment enterprises as in the US context; they are instead defined as enterprises owned by “natural persons” (*ziranren*), therefore do not include “limited liability corporations” or “share-holding corporations limited” that have corporate “legal person” (*fa ren*) status (Huang 2009). They are mostly small businesses. In 2012, there were a total of 10.9 million such enterprises registered with a total of 113 million workers (including those registered in

¹²² State-holding enterprises refer to those mixed-ownership enterprises where the government has a larger share of the equity capital than any other shareholder. See “Explanatory Notes on Main Statistical Indicators” in the China Labor Statistical Yearbook.

both urban and rural areas thus the number is greater than 75.6 million in the urban private enterprises presented in Table 3.1), making for an average of only 10 workers per enterprises, including the employers of such enterprises.¹²³ The average number for 2007 is 13 workers per enterprise, suggesting that the size of the urban private enterprises has a declining trend.¹²⁴ Workers in such small-scale enterprises usually enjoy little benefits or job security or labor law protection (Huang 2009). Although informal employment usually includes those working in micro-enterprises according to Organization for Economic Cooperation and Development (OECD), an enterprise of average size of 10 people cannot be counted as micro enterprises (which strictly require number of employees as no more than 10 people, instead of on average) based on the European Commission standard (Jutting et. al 2008).¹²⁵ However, in this paper, I still include this category based on a general consensus in the literature on Chinese informal economy.

The self-employed persons (e.g. small-shop and stall owners, artisans and apprentices, proprietors of small eateries and food stalls, repair shop owners, etc) represent about 86.3 million over 41 million entities, making for an average of 2.1 employed persons per entity—usually the person registered together with a relative or friend.¹²⁶ This number does not change much from 2007 with about 2 employed persons per entity.¹²⁷ Not surprisingly this group of people do not enjoy benefits and job security (Huang 2009).

¹²³ Calculated by author based on Table 4-8 Number of Engaged Persons in Private Enterprises at Year-end by Region (2012), China Statistical Yearbook (2013).

¹²⁴ Calculated by author based on Table 4-14 Number of Engaged Persons in Private Enterprises at Year-end by Region (2007), China Statistical Yearbook (2008).

¹²⁵ See European Commission, What is an SME at http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm, retrieved on October 19, 2014.

¹²⁶ Calculated by author based on Table 4-9 Number of Self-employed Individuals at Year-end by Region (2012), China Statistical Yearbook (2013).

¹²⁷ Calculated by author based on Table 4-15 Number of Self-employed Individuals at Year-end by Region (2007), China Statistical Yearbook (2008).

Finally, there are about 90 million unregistered urban informal employees (recorded as “not formally counted” in Table 3.1), who are working as domestic helps, delivery workers, street vendors, and the like, with even lower levels of job security (Huang 2009).

The three main groups of the urban informal economy (private enterprises, the self-employed, and the unregistered) add up to a composite picture of low pay, little job security, few or no benefits, and no protection under state labor laws. These characteristics are consistent with the features of informal economy defined by the International Labor Organization (ILO).¹²⁸

3.4.5 Constructing employment-output (E/O) ratios for the informal sector

In this paper, employment in the informal sector refers to those working in the urban sector yet either employed by the small and medium private enterprises, or as self-employed, or not formally counted by the national statistics. Rural informal employment, however, is not included due to the potential complication it could cause. These people, about 83 million people in 2007 and 103 million in 2012, usually work at “township and village” industries (usually manufacturing and construction sectors), or service sectors including transportation (e.g. truck drivers), trade (e.g. owners of small shops) and social services (e.g. barbers, repairmen) (Huang 2009).¹²⁹ The literature on Chinese labor does

¹²⁸ According to ILO, the characteristic features of informal employment are lack of protection in the event of non-payment of wages, compulsory overtime or extra shifts, lay-offs without notice or compensation, unsafe working conditions and the absence of social benefits such as pensions, sick pay and health insurance. See <http://ilo.org/global/topics/employment-promotion/informal-economy/lang--en/index.htm>.

¹²⁹ The 2012 data are based on *National report on rural migrant workers in 2013*, published on May 12th, 2013 and retrieved on October 5, 2014. See http://www.stats.gov.cn/tjsj/zxfb/201405/t20140512_551585.html. The exact data for 2007 is not available. The 83 million data in the paper is a simple extrapolation based on 80 million in year 2006 (Huang 2009) and 85 million in year 2008 from *National report on rural migrant workers in 2013*.

not have a consensus on measuring the rural informal economy. Some would only consider the rural non-agricultural workers who do not migrate to urban sector and are locally employed in rural, nonagricultural informal units as included in rural informal employment; Others argue that all rural employment should be considered informal (even including all the agricultural-related activities) because of the seasonal features of agricultural work, which could be as high as 476 million.¹³⁰ This paper has counted the agricultural employment into the calculation of bioenergy employment generation.

Constructing the employment data for the informal economy mainly rely on three sources. First, I refer to the employment data on the three strata of the economy (i.e. primary, secondary and tertiary).¹³¹ Second, I use the employment data on the urban private enterprises and self-employment for seven industrial sectors.¹³² Third, I also use the urban employment composition in Table 3.3 as a reference to disaggregate employment for industrial sectors that only have very high level of aggregation.

Constructing informal employment data for agricultural-related sectors is straightforward. The three strata data provides the total employment of agricultural-related activities. When this data is subtracted by the formal employment in agricultural-related activities we used for calculating the formal employment-output ratio, then we will have the informal employment data for the five aggregated-related sectors including cropping, forestry, animal husbandry, fishery and service sector related to the these four

¹³⁰ See Huang (2013), Restudy the Chinese laborers—historical evolution of labor law and the contemporary informal economy, at <http://wen.org.cn/modules/article/view.article.php/4006>, published at Oct 2013, retrieved at October 28, 2014.

¹³¹ See Table 4-4 from China Statistical Yearbook (2008). The primary industry includes agriculture, forestry, animal husbandry and fishery; Secondary industry includes mining, manufacturing, power sector and construction sector; Tertiary industry includes everything else.

¹³² See Table 4-13 from China Statistical Yearbook (2008). The seven industrial sectors are manufacturing; construction; transport, storage & post; wholesale and retail trades; hotel and catering services; leasing and business services; services to households and other services.

sectors. To get an average informal employment-output ratio for the five agricultural-related sectors, we divide the total informal employment by the aggregated gross output for these five sectors.

Constructing informal employment for non-agricultural sectors are more complicated. In order to take advantage of all the available information regarding Chinese informal economy, I break down the calculation of informal employment into two categories: the group of people working in private enterprises or as self-employed (P&S), as well as the group of those not formally counted.

For those working in the P&S, data are available for only seven sectors of high level of aggregation, amounting to 70 million in total. They are manufacturing; construction; transport, storage & post; wholesale and retail trades; hotel and catering services; leasing and business services; services to households and other services. The difference between the 70 million and the 78.9 million (see Table 3.3) of total employment in the P&S is the P&S employment for the remaining sectors in addition to the seven sectors, or 98 sectors by the details of aggregation as in the I-O model by 135 sectors. Then these 8.9 million workers are allocated to the remaining 22 non-agricultural sectors in the I-O model according to the formal employment composition in these 22 sectors.¹³³ Thus we have the informal employment for all the non-agricultural sectors.

The second category of workers who are not formally counted in the national statistics amounts to 94.4 million in total (Table 3.3). They are allocated to the 130 non-agricultural sectors according to the composition of P&S employment in those 130

¹³³ This allocation method assumes relatively similar formal and informal employment ratio in different sectors. Although the assumption might not hold for certain sectors, this is the best available method given the data limitation in the Chinese informal economy. 22 is the result of subtracting 135 sectors by the 5 agricultural-related sectors and the 98 sectors with data available on the private enterprises.

sectors calculated from the previous step.¹³⁴ The two categories of workers constitute the whole urban informal economy this paper focuses on estimating. Dividing this employment estimate by the gross output for each of the 130 sectors will give the informal employment-output ratio for these sectors.

3.4.6 Weighting the renewable energy sector

3.4.6.1 Selection of three kinds of renewable energy for in this paper

This section will focus on estimating the cost components of three kinds of renewable energy that are of high relevance in the Chinese context, namely, solar power, wind energy and bioenergy.¹³⁵ The reasons for the selection are explained below.

According to China's Twelfth Five-Year Plan on energy development, installed capacity of solar power is expected to reach 21 GW in 2015, amounting to an annual growth rate of 89.5 percent from 0.86 GW in 2010.¹³⁶ For reaching the 21GW target, the main factor is solar Photovoltaic (PV) technology—solar thermal power only accounts for 3GW. Thus, our calculation of the employment generation from developing solar energy will mainly focus on the solar PV sector.¹³⁷

¹³⁴ This allocation method assumes relatively stable ratio between those not formally counted in the national statistics and those counted as working for private enterprises or as self-employment in all the non-agricultural sectors. Although this assumption might still not hold for certain sectors, it is a more realistic assumption than the one I use for allocating the employment group of private enterprises and the self-employed. And again, this is the best available method given the limited information on the Chinese informal economy.

¹³⁵ This paper will focus on studying the employment effects of solar PV, on-shore wind and low-emission bioenergy. The reasons will be discussed in detail in section 4.3.1 though 4.3.3.

¹³⁶ Source: State Council January 23, The Twelfth Five-Year Plan on Energy Development.

¹³⁷ China to install 3000GW solar thermal power by 2015. Nov 2012. Extracted from website on May 15, 2014. http://www.chinadaily.com.cn/business/2012-11/22/content_15950340.htm

Wind energy installation capacity is expected to reach 100 GW in 2015, requiring an annual growth rate of 26.4 percent from 31GW in 2010. Since wind energy is experiencing rapid development in China, it is included in the calculation.

On the other hand, the expected installation capacity of hydropower is 290GW in 2015 from the already existing 220GW in 2010. This essay excludes hydropower in the calculation for two reasons. First, hydropower has been well developed in China and there is limited potential for another round of major increases in hydropower installation. Thus, it is not of high relevance to the employment generation we are discussing here (Martinot and Li 2007; REN21 2012).¹³⁸ Second, counting hydropower as renewable energy has become controversial due to the impact of dams on fisheries and water flows.¹³⁹

Last but not least, China's bioenergy production is estimated to exceed 50 million tons of standard coal by the end of 2015, and biomass electricity is expected to achieve 13 million kilowatts capacity.¹⁴⁰ Since the biomass energy sector contains significantly higher employment-output ratio than other renewable energy sectors based on the world experiences, I include the calculation of employment generation of biomass energy despite its relative underdevelopment in China for policy recommendation purpose.

¹³⁸ According to REN21 (2012), China's capacity exceeds that of Brazil, the USA and Canada combined.

¹³⁹ Is hydropower a renewable energy or not? September 2013. Extracted from the internet on May 15th 2014. <http://www.governing.com/topics/transportation-infrastructure/gov-hydropower-renewable-energy.html>

¹⁴⁰ Based on China's 12th Five Year Plan (2011-15). The plan has outlined the following targets: Biomass Electricity: 13 million kilowatts capacity; Biogas Annual Utilization: 22 billion cubic meters; Solid Biomass Fuel Annual Utilization: 10 million tons liquid; Biofuels Annual Utilization: 5 million tons. Hereby, bioenergy investment is expected to increase to 140 billion RMB (or 22.6 billion USD at 2012 price level) with 100 billion annual sales turnover. Source: <http://www.bbs-summit.com/en/>, retrieved on September 27, 2014.

3.4.6.2 Necessity of country-specific weights

It is necessary that our estimates be based on cost components that are specific to China. Figure 3.1 presents the cost components for renewable power generation technologies by regions covering OECD countries, Africa, Eastern Europe and Central Asia, China, India and Latin America. As we can see, cost per kWh for the same kind of renewable technology can vary widely among different regions. For example, biomass energy costs about 0.06 to 0.29 USD/kWh in OCED European countries yet its cost in China ranges from 0.02 to 0.08 USD/kWh. Even within the same country, the cost structure of the solar industry in 2007 looked very different than it does now, due to the rapid technological development of the industry and the resulting significant decline in the costs of raw materials.

Table 3.4 presents the estimation for the cost components of the solar industry conducted by China Solar PV Report 2007. We can see that the largest cost share comes from purchasing silicon materials (i.e. 45.2 percent of the total costs), while installation only accounts for 3.6 percent. This pattern is surely very different from the US case, yet it is hardly surprising for two reasons. First, the data in Li et.al (2007) are collected when the price for polycrystalline silicon was 470 USD/kg, a price that experienced about a 97 percent decline over the next five years.¹⁴¹ Second, the installation costs measured by Li et.al (2007) listed only the in-grid type, which contains the lowest costs among all types of installation (IRNEA 2012a). Therefore in the following sections, I will mainly use the

¹⁴¹ In 2012, the silicon price fell to only 20 USD/kg for leading Chinese polycrystalline silicon manufacturers, and 12 USD/kg for international leading manufacturers. From News on the 2013 China Solar PV Report. See: http://www.pv-tech.cn/guest_blog/semi_deliver_report_of_2013_pv_industry/P1. In the first quarter of 2014, the price has risen to 20.3 USD/kg. See Mike Munsell, *Fastest Quarterly Growth in Polysilicon Prices since 2010*, at <http://www.greentechmedia.com/articles/read/Fastest-Quarterly-Growth-in-Polysilicon-Prices-Since-2010>, published on April 4th, 2014 and retrieved on September 27, 2014.

latest available literature on the cost components of renewable energy technology, combined with China-specific information, to indicate the changes in recent years.

3.4.6.3 Solar PV

Table 3.5 presents the capital cost structure of a PV system, composed of the PV module cost and the balance of system (BOS) cost (IRENA 2012a). According to the IRENA (2012a) definition, the PV module cost is determined by raw material costs, notably silicon prices, cell processing/manufacturing and module assembly costs. The BOS cost includes the cost of the structural system (e.g. structural installation, racks, site preparation and other attachments), the electrical system costs (e.g. the inverter, transformer, wiring and other electrical installation costs) and the battery or other storage system cost in the case of off- grid applications (p 15).¹⁴² Note that the module cost data in the upper part of the table are the average world price level, while the BOS costs in the lower part are estimated based on US data (IRENA, 2012a). Since the average selling price of solar PV modules has already converged among nations including China, the cost structure among countries should not vary significant.¹⁴³ The real gap between countries, as will be shown later, lies in the installation costs. Therefore in this paper I will apply the cost structure information for all the other costs except the installation based on the Table 3.4 information.

¹⁴² Note that the use of BOS is slightly different in IRENA (2013, p51), where BOS are used to refer all costs excluding both the module costs and the installation costs. Here we still use BOS as including the installation costs for convenience.

¹⁴³ Solarbuzz November 30, 2012: Installed PV system continue to exhibit strong global variations. <http://www.solarbuzz.com/resources/analyst-insights/installed-pv-system-costs-continue-to-exhibit-strong-global-variations>

From Table 3.5, we can see that the installation costs for solar PV vary with the nature of the installation. For utility-scale PV plants, it can be as low as 20 percent (for a simple grid- connected system) or as high as 70 percent (for an off-grid system). For residential and small-scale systems, the BOS and installation costs make up 55 percent to 60 percent of total PV system costs. This variation also applies across countries (IRENA 2013).

Table 3.6 gives the cost structure for the Chinese Solar PV industry in 2012. From the available information, we can calculate the installation costs for a utility-scale ground-mounted system as 0.5 USD/Watt, which is about 23 percent of the total costs, very different from the information presented in Table 3 which is based on 2007 data.¹⁴⁴

Applying the information from Table 3.5 (all but the installation costs) and Table 3.6, Table 3.7 presents the cost structure in detail for the Chinese Solar PV industry. Notice that this number is only for the utility-scale ground-mounted version. I also included the Table 3.4 information on the 2007 cost structure for comparison. Table 3.8 presents the industries and weights for solar energy matched to the I-O model used in estimation.

3.4.6.4 Wind

Wind energy in China consists of two main categories: onshore and offshore wind power. According to IRENA (2013), offshore wind power installation usually has a much higher construction cost share than the onshore wind power installation (25 percent versus 10 percent). However, since offshore wind power constitutes less than 1 percent of

¹⁴⁴ Total installed costs minus PV module costs minus BOS costs (except installation costs). The percentage is calculated by 0.5 divided by 2.2

the total installed wind power in China, the analysis in this paper will focus on the onshore wind power case.¹⁴⁵

Table 3.9 presents the world average cost structure of on-shore wind energy investment and the estimated cost structure for the Chinese case. Column by column, I show how I use the world average statistics on wind energy structure from IRENA (2012b) and IRENA (2013) to work out the China's specific cost structure through combining the information on China's total installed costs of on-shore wind energy. For example, column 1 and 2 show the world average statistics on the detailed cost components of wind energy sector. Column 3 transforms the weights of the components in the turbine building costs to the total costs. Column 4 applies these specific weights to the context of China with consideration of the feature of low-cost turbines and low total installed costs as well. As a result, total installed costs of wind energy in China amount to only about 1300 USD/kW in 2011, compared with the world average of 1700 to 2150 USD/kW (IRENA 2012b). The last column aggregates the information in the previous columns. Table 3.10 presents the industries and weights for wind energy matched to the I-O model used in estimation.

3.4.6.5 Bioenergy

Bioenergy can be used either directly through combustion to produce heat, or indirectly after being converted to various forms of biofuel. Currently China's biomass energy sources mainly come from agricultural stalks, animal manure, forestry sources

¹⁴⁵ By the end of 2012, China had only installed 389.6 Megawatt (MW) offshore wind capacity, while the total installed capacity for on-grid wind power has reached 60830 MW. Source: China unable to achieve 5GW offshore wind goal by 2015 (<http://www.windpowermonthly.com/article/1187293/analysis---china-unable-achieve-5gw-offshore-wind-goal-2015>) & China National Renewable Energy Center.

and bioenergy crops, and are used to produce heat, electricity, solid fuel, liquid fuel (biofuel ethanol, biodiesel, biofuel), and gasified fuel (methane gas, biogas and hydrogen). These are used by households (e.g. cooking and heating) and in transportation and electricity provision (Tian et. al 2011).

For the purpose of estimating meaningful employment opportunities, this paper focuses the estimation for biofuel. More specifically, this paper estimates the employment impacts from using biofuel that relies on the “beneficial” biomass resources defined by the Union of Concerned Scientists.¹⁴⁶

3.4.6.6 Combustion

Although using biomass sources to produce heat contributes to the reduction in consuming non-renewable energy sources, its employment impacts are not very significant. This is because the production and consumption of such energy takes place in individual households—collection of biomass sources (e.g. agricultural stalks and animal manure) involves negligible costs. The same applies to transportation costs of the energy (from outside the house where sources are picked up to inside house where heat is generated for cooking and heating purpose). All in all, even though labor and time are involved, they are largely undercompensated and are not considered to be a job as long as an industrial scale of production is not achieved. Employment generation occurs in the industrial sector that produces firewood stoves, which represent the only considerable

¹⁴⁶ The Union of Concerned Scientists terms “beneficial” biomass resources that meet the following standards. First, energy crops that do not compete with food crops for land; Second, portions of crop residues such as wheat straw or corn stover; Third, sustainably harvested wood and forest residues; Fourth, clean municipal and industrial wastes.

costs (200 RMB per firewood stoves, or 32 USD) involved with household's use of biomass energy (Tian et.al 2011).

Given the limited employment impacts of direct use of biomass, this paper does not include combustion as an important source for employment generation.

3.4.6.7 Biogas

The Chinese government has been supporting the development of the biogas industry in rural China since 1958.¹⁴⁷ The use of methane gas technology (specifically rural household methane gas and breeding farm methane gas) has been developed to a considerable scale mainly because the main sources that methane gas relied on—rotting garbage, agricultural and human waste—are easily accessible and do not threaten food security (Tian et.al 2011).¹⁴⁸ However, biogas industry is developed for local use mostly and therefore it does not involve significant transportation costs such as in the biofuel industry. Also the main sources that biogas relies on does not involve agricultural activities that create significant amount of jobs. Therefore despite the fact that biogas is used at a much larger scale than biofuel in China at the moment, this paper does not include employment estimates for biogas due to its limited potential for employment generation (USDA FAS 2013).

¹⁴⁷ China's renewable energy development history: 1958-1008. Retrieved from Gansu Website of China, <http://www.gscn.com.cn/pub/special/2009zt/gsxny/xny/2009/07/13/1247456273000.html>, September 26, 2014.

¹⁴⁸ According to Tian et. al (2011), other types of biomass energy (such as for solid fuel or methane gas from stalks) are still in the preliminary stage for commercialization.

3.4.6.8 Biofuel

When a biomass energy source is converted into liquid form, it becomes biofuel. However, it is important to note that whether biofuel (i.e. ethanol and biodiesel) contributes to environmental sustainability will depend on its production processes. A 30-year lifecycle analysis suggests that the overall level of greenhouse gas emissions of corn ethanol refined through coal-fired processing is actually 34 percent higher relative to that of burning gasoline.¹⁴⁹ Instead, the way to achieve major emission reductions is by burning waste-grease biodiesel, corn stover ethanol, or switchgrass ethanol (Pollin et. al. 2014b).

Biofuel development is extremely labor-intensive from the world experience (Raswant et.al 2008), but it also raises the issues of food security especially in the developing countries (FAO 2008; Raswant et.al 2008; FAO 2013; Pollin et.al. 2014b). In China, corn-based ethanol production has been constrained since 2007 due to its potential threat to domestic food security.¹⁵⁰ Alternative crops, like sweet sorghum or cassava, that grow on marginal land have relatively low yields and small-scale production, therefore have limited potential to support large-scale industrial ethanol production unless China seriously expands its production bases to mid-west regions or coastal saline areas (USDA FAS 2013).¹⁵¹ Moreover, development of sorghum or cassava-based biofuel would not

¹⁴⁹ U.S. Environmental Protection Agency, 2009, May. "EPA Lifecycle Analysis of Greenhouse Gas Emissions from Renewable Fuels," Office of Transportation and Air Quality. EPA-420-F-09-024. Retrieved from: <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockkey=P100B3F8.txt>

¹⁵⁰ Since then the trend of biofuel production has been reversed. The realized fuel ethanol production in 2010 was only 1.86 million tonnes with 0.37 million tonnes using non-grain feedstocks", far short of the target of 2 million tonnes of non-grain fuel ethanol consumption (Chang et.al 2012).

¹⁵¹ To ensure a domestic feedstock supply for biofuel production, China will need to expand its production bases in Inner Mongolia and Xinjiang, two regions with substantial sunshine and heat resources suitable for the planting of sweet sorghum, as well as in the Bohai Rim Region, where a five million-ton fuel ethanol production base can be built in the region's large saline areas, as proposed by the government think tank Institute of Nuclear and New Energy Technology at Tsinghua University. See Liu Yuanyuan, *China seeks to develop biofuel industry despite production difficulties*. April 24, 2012, at

have a massive impact on employment generation unless China changes its current importer role and seriously starts to grow the feedstock domestically, since feedstock accounts for about 50 percent of the total cost of electricity produced by biomass technologies in China (Chang et.al 2012; IRENA 2013, p66).¹⁵²

Despite government's tight control on all kinds of grain-based ethanol production, majority feedstocks for biofuel in production are still grain-based mainly because the technological development for alternatives was lagged behind.¹⁵³ This also explains why biofuel development is stagnating in China.¹⁵⁴

In addition, China's biodiesel industry still lacks a large scale of industrial production mainly due to the high cost and therefore inconsistent supplies of feedstocks (i.e. grease waste, or waste cooking oil).¹⁵⁵ Even today, no national or provincial mandate exists for biodiesel usage (USDA FAS 2013). This paper excludes biodiesel in the biofuel employment calculation.

The choice of feedstocks for biofuel production in China should be based on the following standards. First, they must be "beneficial" sources in the sense that they neither threaten food security nor incurring more GHG emission than burning gasoline; second,

<http://www.renewableenergyworld.com/rea/news/article/2012/04/china-seeks-to-promote-development-of-biofuels-industry-despite-production-difficulties>, retrieved September 27, 2014.

¹⁵² Remarks retrieved from the introduction of Division of Biofuels and Bio-chemicals, Institute of Nuclear and New Energy Technology, Tsinghua University, on December 25, 2013, at <http://www.inet.tsinghua.edu.cn/publish/ineten/5761/index.html>

¹⁵³ According to USDA FAS (2013), 64 percent of fuel ethanol production in China was sourced from corn, 30 percent from wheat and 6 percent from cassava in 2012.

¹⁵⁴ Although the National Energy Bureau of China announced ambitious goal for developing biofuel, it still only accounts for less than one percent of China's liquid fuel production in 2013. See USDA FAS 2013; A spokesperson for the National Energy Bureau said that the Chinese government has set a goal of utilizing five million tons of ethanol fuel during the "12th Five-Year Plan" period spanning 2011 to 2015, nearly doubling the goal set for the prior period (2006-2010). See Liu Yuanyuan, *China seeks to develop biofuel industry despite production difficulties*. April 24, 2012, at <http://www.renewableenergyworld.com/rea/news/article/2012/04/china-seeks-to-promote-development-of-biofuels-industry-despite-production-difficulties>, retrieved September 27, 2014.

¹⁵⁵ China new energy network. Why is the Chinese biodiesel industry developing so slow? See: <http://www.newenergy.org.cn/html/01211/11211250543.html>. Retrieved Oct 9, 2013. Also see USDA FAS (2013) for relevant discussion.

they should have minimal demand for soil quality (e.g. saline soil, desert, grassland, etc) given China's already serious land intensiveness; third, they need to be labor-intensive (i.e. involve massive agricultural activities) to ensure significant amount of employment opportunities.

Perhaps there is no single feedstock that meets all the standards. Switchgrass, for example, demands lowest soil quality and contains largest amount of emission reduction, yet its flexibility of growing conditions implies that it does not involve much agricultural activities that are the main sources of job creation.¹⁵⁶¹⁵⁷ Therefore a combination of different feedstocks is necessary for reaching the best outcome of biofuel development before any technological breakthrough.¹⁵⁸

3.4.6.9 Cost breakdown

The costs for generating bioenergy power include three critical components (IRENA 2013). The first part occurs in the process of growing biomass feedstocks. Feedstock cost usually represents 40 percent to 50 percent of the total cost of electricity produced by biomass technologies, varying by the transportation costs, labor costs involved and the quality of the biomass sources (IRENA 2013, p66). Prices for the biomass sources range between USD 10/tonne to USD 160/tonne (IRENA 2013, p67).

¹⁵⁶ According to Pollin et.al (2014b), switchgrass-based biofuels have emission level 124 percent lower than the gasoline. See Table 3.5 Greenhouse gas emissions reductions for alternative biofuels and biomass energy sources.

¹⁵⁷ National Energy R&D Center for Non-food Biomass (NECE), *Switchgrass*, published on March 13th, 2013 at <http://necb.cau.edu.cn/ylzy/nyzw/lzj/2013-03-13/520.html>, retrieved on September 27, 2014.

¹⁵⁸ Research and development for non-grain based biofuel production is still ongoing. See China Science Newspaper *Biomass: Grain and energy can coexist* at <http://news.bioon.com/article/6655908.html>, published on July 25th, 2013, retrieved on September 27, 2014.

The second cost component arises when biomass feedstocks are transformed into the energy form that will be used to generate heat and/or electricity, or in most cases, when biomass is transformed into biofuel. This includes the cost for the equipment (prime mover and fuel conversion system), fuel handling and preparation machinery.

The last cost component is generated during the use of power generation technologies, including engineering, construction and planning costs. It also includes grid connection, roads and new infrastructure required for the project (IRENA 2013, p68). For non-OECD countries, such costs are estimated to be in the range of USD 600 to USD 1400/kW (IRENA 2013,p68).

Based on the statistics for some non-OECD countries, I use an average of the costs to represent the cost breakdown for China. The weighting for relevant sectors of biomass energy is shown in Table 3.11 below. Table 3.12 presents the industries and weights for bioenergy matched to the I-O model used in estimation.

3.4.7 Traditional fossil fuel sectors

3.4.7.1 Coal

UNEP et. al (2008) found that modern coal-fired power plants are becoming much less labor-intensive than a decade ago. Specifically, nowadays a coal plant employs about 270 workers for a 1200-megawatt facility, compared with older plants employing up to 1000 workers for a 50 to 100-megawatt facility (p91). However, developing countries are still lagging behind advanced nations in applying the technology to reduce the labor-intensiveness in the coal sector.

The coal sector in China distinguishes itself in its heavily weighted component of transportation costs. Since most coal mining activities are conducted in the western and northern part of China while major coal demand occurs in the eastern and southern part of China, coal transportation cost usually makes up about 55 percent to 60 percent of the consumer-end electricity costs (Mao et. al 2008). In addition to the transportation costs, coal-fired energy production costs include production costs on the coal-mining sites as well as the actual electricity generation costs occurred in the coal-fired power plant. Xie et.al (2011) show that 88 percent of the coal-fired power generation costs come from the coal products (including the mining, processing and transportation) and the rest (i.e. electricity distribution and other related services) only constitute 12 percent. Depending on these pieces of information from the existing literature, I construct the industries and weights for coal energy as in Table 3.13 matched to the I-O data.

3.4.7.2 Oil/Natural Gas

The reason to combine oil and natural gas in the same industry, although they have a slight difference in their cost structure to produce energy, is that they are also combined in the input-output table. The process of using oil/natural gas to produce energy mainly depends on activities in mining, transportation, refining and chemical product manufacturing, as well as management-level activities (Cui et.al 2008). Table 3.14 presents two case studies of oil production cost structure. The weighting adopted in this paper is based on their average. Table 3.15 presents the industries and weights for oil/ natural gas sector matched to the I-O model used in estimation.

3.5 Results and discussion

3.5.1 Employment generation per million of USD

Table 3.16 through 3.19 present the full set of results in terms of job created per \$1 million USD spent in both renewable energy and fossil fuel sectors.

As we can see (Table 3.16), the bioenergy sector generates highest number of jobs with the same amount of spending level, with 224 direct jobs per \$1 million. This contrasts with a range of about 27-29 for solar and wind energy due to the significant amount of agricultural-related activities involved in bioenergy production. It is also significantly higher than the direct jobs generation in the fossil fuel sectors, with range between 30 to 70 jobs per \$1 million. In terms of indirect jobs—those jobs generated through the supply chains associated with renewable energy production—the three kinds of renewable energy sectors show relatively consistent estimates, about 60-70 jobs per \$1 million, and is much higher than the fossil fuel sectors with range between 40 to 50 jobs per \$1 million.

If equal weights are assigned across the three renewable energy sectors, then results suggest that spending \$1 million on renewable energy generates about 162.3 jobs, including 93.1 direct and 69.2 indirect jobs on average. This contrasts with only 96.7 jobs, including 49.5 direct and 47.1 indirect jobs, generated from \$1 million overall spending on both coal and oil/gas.¹⁵⁹

The results suggest that, for China, spending on the clean energy economy (with a combination of the three kinds of renewable energy focused in this paper) will produce about twice as many jobs per dollar of expenditure than an equal amount of spending on

¹⁵⁹ This average number is also calculated by assigning equal weights to the two fossil fuel sectors.

fossil fuels. Thus a clean energy investment strategy will not destabilize the overall employment level in China relative to the investment strategy biased towards the fossil fuel energy sectors.

3.5.2 Composition of Employment

The informal workers mainly concentrate in the mining, construction, manufacturing, transportation sectors, which are also the significant components for the renewable energy and fossil fuel sectors. Table 3.17 presents the composition of employment in terms of formal and informal employment. As we can see, the bioenergy sector is constituted mostly (261 jobs or 90 percent of jobs) by employment in the informal economy. Those are the people growing or logging for bioenergy feedstock, as well as workers engaged in manufacturing equipment and machinery to transform feedstocks into the energy form that will be used to generate heat and/or electricity.

On the other hand, three quarters of employment (or about 75 jobs per \$1 million) created by solar and wind energy sectors are within the informal economy. Workers in the construction sector constitute a significant portion. Specific manufacturing sectors also contribute to the informal component of jobs in these two sectors. They include manufacturing of power transmission equipment and mining machinery for the solar energy sector (i.e. for the mining of polycrystalline silicon materials crucial for building solar panels), as well as manufacturing of metal products and other sectors related with building wind turbines.

The fossil fuel energy sectors also have a high level of informal employment composition. In the oil and natural gas sector, 20.9 jobs (or 81 percent of the jobs)

generated from \$1 million spending are within the informal economy. These are mostly workers on the field extracting oil and natural gas, corresponding to the informalization of the state-owned oil and natural gas enterprises in the recent decade. With respect to the coal energy sector, 78.6 jobs (or 70 percent of the jobs) generated from \$1 million spending are within the informal economy. These are mostly workers in the railway transportation, mining and coking sectors.

It is important to note that the amount of informal employment generation might be overestimated either due to the inclusion of small and medium scale private enterprises, or the fact that the final demand is only raising earnings instead of generating new employment especially for the self-employed population (as discussed in section 4.5).

3.5.3 Cumulative employment generation

In addition to the estimates of employment generation in terms of jobs per 1\$ million, this section presents the projection of the cumulative employment generation (jobs generated over certain time period). The difference here lies in the nature of the employment estimates as flows or stocks. Table 3.20 presents the cumulative employment generation for solar, wind and bioenergy according to the investment target in the 12th Five Year Plan period (2010-2015). Based on my estimation, the cumulative formal employment generation in the three renewable energy sectors adds up to 3.7 million, among which direct jobs accounts for 1.7 million. When informal employment is included, the cumulative employment generation in the three sectors adds up to 19.1 million, among which direct jobs accounts for 8.5 million.

Table 3.21 presents the cumulative employment generation in the wind sector supposing the investment targets announced in the National Development and Reform

Commission are met. As we can see, the wind sector could generate about 12.5 million new jobs from 2010 to 2020 through investing a total of 264.4 billion USD, 57.2 million new jobs from 2010 to 2030 through 571.8 billion USD investment and 180.6 million new jobs from 2010 to 2050 through 1804.1 billion USD.

Among these jobs generated, 6.5 million, 14.1 million and 44.6 million respectively are in the formal sector. If we take the annual average employment generation from the three ranges of years to approximate employment generation for the end-year for each period respectively, then we can roughly estimate that the wind sector generates 1.3 million jobs in year 2020, 2.9 million jobs in year 2030, and 4.5 million jobs in year 2050. This total employment in both formal and informal sectors would compare to 0.1, 0.3 and 0.6 percent of the labor force for year 2020, 2030 and 2050 respectively.¹⁶⁰

Employment estimates for bioenergy and solar sectors are based on the assumption that investment in these two sectors follows the same growth rate as in the wind sector. The solar sector will generate relatively fewer employment opportunities than the wind sector, yet the numbers are still significant. Specifically, the solar sector will generate about 12.5 million new jobs by 2020, 27 million by 2030 and 85.1 million by 2050, among which 3.1 million, 6.7 million and 21.3 million are in the formal sector respectively, all relative to the 2010 level. The bioenergy will generate the largest number of jobs especially when informal employment is included. Specifically, it will generate employment for about 35.7 million new jobs by 2020, 43.3 million by 2030 and 136.6 million by 2050, among which 1.7 million, 3.8 million and 11.9 million are in the formal

¹⁶⁰ According to United Nations World Population Prospects (r. 2012), China's working-age population (age 15 to age 60) will be 929, 875 and 700 million respectively for year 2020, 2030 and 2050, assuming constant fertility. See Table Population by Age Groups- Both Sexes at <http://esa.un.org/wpp/Excel-Data/population.htm>

sector respectively, compared with the 2010 level. However, it should be noted that the formal and informal employment proportions in China should shift in favor of formal employment by year 2050. Therefore the estimates for the informal employment could be overestimated by then.

3.5.4 Output-Investment Ratio (output multipliers)

In this section, I compare the output multipliers over time to show their relative stability for all energy sectors in the past decade.¹⁶¹ The output multipliers tell the amount of output increase as a result of increase in final demand therefore providing information on the production relationships between sectors in the I-O table. The data was taken from the World Input-Output Database (WIOD), a project of the European Commission, which produces annual national I-O tables for a selected number of countries. For China, the WIOD tables are more aggregated (i.e. 35 sectors) than the one I used to produce the employment estimates in this paper (i.e. 135 sectors). I use the same weighting schemes that were applied to produce employment estimates to estimate output multipliers for synthetic sectors of both renewable and fossil fuels—the energy sectors that are not readily available in the original I-O tables. Table 3.22 presents the results.

As we can see, for all the energy sectors, the annual average percentage changes in the output multipliers from 1995 to 2007 are negligible (all within the range of 1 percent in absolute values).¹⁶² This concludes that the production relationships between the

¹⁶¹ Output multipliers are calculated from the Leontief inverse for each of the four countries. The Leontief inverse matrix is given by $L=(I-A)^{-1}$ in which L is the Leontief inverse matrix, I is the identify matrix, and A is the matrix of I-O coefficients derived from the WIOD tables.

¹⁶² I intentionally choose year 2007 as end point to avoid cyclical complication by the 2008 economic crisis.

domestic sectors in China did not change significant over the 12-year period between 1995 and 2007. This conclusion addresses the concerns for not incorporating dynamic elements in the model. It is now reasonable to assume that output multipliers would change only at a modest pace over the next two decades for which employment projection will be made.

On the other hand, changes in output multipliers from 2007 to 2011 vary among different sectors. Solar, wind and coal energy sectors still show relative consistent production relationships (with the range of changes in output multipliers within 1 percent in absolute values). Yet bioenergy and oil/gas sectors show moderately fast annual average changes in output multipliers (1.1 percent and -1.3 percent respectively).¹⁶³ However, since the changes are still not very dramatic, it is reasonable to think that the employment estimates will not be improved much by using the 2011 I-O table with only information on 35 aggregated sectors than to use the 2007 I-O table (with a detailed breakdown of 135 sectors) as this paper does.

3.5.5 Productivity and declining Employment-Output (E/O) ratio

Although more updated I-O tables are available for year 2010 (with 54 sectors) and year 2011 (with 35 sectors), the 2007 I-O table still provides the most sufficient details of the production relationship among sectors relevant for energy production. This is why this paper sticks to the 2007 I-O table to provide employment estimates for both

¹⁶³ The decline of output multiplier in oil/natural gas sector in China can be explained by China's growing imports of oil. In 2013, China has become the largest net imports of petroleum and other liquid fuels. See EIA, China is now the world's largest net importer of petroleum and other liquid fuels at <http://www.eia.gov/todayinenergy/detail.cfm?id=15531>, published on Mar 24th 2014, retrieved on October 13, 2014.

renewable and fossil fuel energy sectors. Since I-O table also provides information on gross output by sectors, lack of more updated I-O table with comparable level of details as in the 2007 I-O table means that even though more recent data are available for employment by sector, they are not compatible with the 2007 industry data and therefore cannot be utilized to calculate a more updated E/O ratio at a desired level of detail.

To compensate for the lost information, I calculate the E/O ratio for period 2007 to 2011 to show its general pattern in the post-2007 years, although it is defined more loosely and at a more aggregated level with a different unit compared with the E/O ratio I use for the major estimation.¹⁶⁴ Note that the E/O ratio is simply the inverse of labor productivity therefore an increase in labor productivity will reduce the E/O ratio. I use the same weighting scheme to aggregate relevant sectors to synthetic energy sectors of interest to this paper.¹⁶⁵ The results are presented in Table 3.23.

As we can see, the coal sector has the most significant productivity gain among all energy sectors, almost twice the productivity gain for all renewable energy sectors. This increasing productivity suggests that for the same spending level, the employment generation in the coal sector will be much smaller now than five years ago. Although we observe that coal sector show comparable employment generation per \$1 million relative to the renewable energy sectors in terms of both formal and informal employment, this result suggests that the coal sector will very quickly lose its “advantage” in terms of labor intensiveness. The oil and gas sector does not show productivity gain as dramatic as the

¹⁶⁴ Note that the latest China Statistical Yearbook 2013 did not publish estimates gross output value or the annual average persons by industrial sector consistent with those published in previous yearbooks. Thus I exclude the 2012 data for comparison.

¹⁶⁵ Note that gross output data are not available for all the sectors relevant for the energy sectors (such as R&D and Transportation). Under such circumstances, it is assumed that these sectors with missing information will experience the same productivity changes as the weighted average of productivity changes in other relevant sectors for producing the same kind of energy.

other energy sectors, yet it is already the least labor-intensive energy sector among all. Thus it is reasonable to conclude that renewable energy sectors, compared with fossil fuel energy sectors, have the advantage over fossil fuel energy in terms of job creation in the long run.

3.6 Conclusion

This paper addresses the impacts of transformative renewable energy investment program for China. It focuses on estimating the relative employment impacts of investments in three renewable energy sectors in China, i.e. solar, wind and bioenergy, versus spending within China's traditional fossil fuel sectors i.e. coal, oil and natural gas.

The existing literature has never treated employment impacts of investing in renewable energy in China as a primary concern. Existing estimates either lack a transparent methodological discussion or do not provide a clear definition of employment as a concept. They are therefore incapable of serving as a solid empirical evidence for policy discussions on building a clean energy economy.

This paper mainly builds on the Input-Output model to estimate the employment impacts of renewable energy investment in China. One challenge in using an I-O model to estimate how the increase in spending in certain renewable energy sectors affects the whole economy is that these renewable energy sector activities are not as yet specified into distinct industrial sectors, such as “solar energy sector” or “wind energy sector.” To solve this problem, I use information on the cost components of such investment from the existing literature and then use the existing sectors within the I-O model to construct synthetic renewable energy sectors within China's I-O model. These synthetic sectors—

for solar, wind and bioenergy respectively—are based on the weighting structure that reflects the composition of costs within each specific sector.

Based on this estimation methodology, I find that the bioenergy sector generates highest number of jobs with a given level of spending. That is, I estimate that China's bioenergy sector generates 224 direct jobs per \$1 million of spending. This contrasts with a range of about 27-29 for solar and wind energy. The large difference here is the result of the significant amount of agricultural-related activities involved in bioenergy production. It is also significantly higher than the direct jobs generated through spending within China's fossil fuel sectors, which generate about 30 to 70 jobs per \$1 million of spending. In terms of indirect jobs—those jobs generated through the supply chains associated with renewable energy production—the three kinds of renewable energy sectors show relatively consistent estimates, about 60-70 jobs per \$1 million, and is much higher than the fossil fuel sectors with range between 40 to 50 jobs per \$1 million. If equal weights are assigned across the three renewable energy sectors, then results suggest that spending \$1 million on renewable energy generates about 162.3 jobs, including 93.1 direct and 69.2 indirect jobs on average. This contrasts with only 96.7 jobs, including 49.5 direct and 47.1 indirect jobs, generated from \$1 million overall spending on both coal and oil/gas.

In terms of formal and informal employment, with China's bioenergy sector, to begin with, job creation is heavily weighted toward informal jobs—specifically, about 90 percent, or 261 jobs per \$1 million will be informal jobs. The proportions of informal jobs are somewhat lower—at about 75 percent—with the solar and wind energy sectors.

Within China's fossil fuel energy sectors, informal job creation is about 81 percent in the oil and gas sector and 70 percent in the coal sector.

If the investment target of the 12th Five Year Plan is met, then the total formal employment generation in the three renewable energy sectors adds up to 3.7 million from 2010-2015, among which direct jobs accounts for 1.7 million. When informal employment is included, the total employment generation in the three sectors adds up to 19.1 million, among which direct jobs accounts for 8.5 million.

Supposing the investment targets announced by the National Development and Reform Commission are met, cumulative employment generation in the wind sector will amount to 12.5 million new jobs from 2010 to 2020, 57.2 million from 2010 to 2030 and 180.6 million from 2010 to 2050. Among these jobs generated, 6.5 million, 14.1 million and 44.6 million respectively are in the formal sector. If we take the annual average employment generation from the three ranges of years to approximate employment generation for the end-year for each period respectively, then we can roughly estimate that the wind sector generates 1.3 million jobs in year 2020, 2.9 million jobs in year 2030, and 4.5 million jobs in year 2050. This total employment in both formal and informal sectors would compare to 0.1, 0.3 and 0.6 percent of the labor force for year 2020, 2030 and 2050 respectively.

Based on the same assumption, the solar sector will generate about 12.5 million new jobs by 2020, 27 million by 2030 and 85.1 million by 2050, among which 3.1 million, 6.7 million and 21.3 million are in the formal sector respectively, all relative to the 2010 level. The bioenergy will generate the largest number of jobs especially when informal employment is included. Specifically, it will generate about 35.7 million new jobs by

2020, 43.3 million by 2030 and 136.6 million by 2050, among which 1.7 million, 3.8 million and 11.9 million are in the formal sector respectively, relative to the 2010 level. However, it should be noted that the formal and informal employment proportions in China should shift in favor of formal employment by year 2050. Therefore the estimates for the informal employment could be overestimated by then.

The overall implication of this study is that a clean energy investment strategy will not destabilize the overall employment level in China relative to the investment strategy biased towards the fossil fuel energy sectors. The challenges of raising job quality standards in China's energy economy will nevertheless remain substantial.

3.7 Bibliography

Alvarez, Gabriel Calzada, Raquel Merino Jara, Juan Ramon Rallo Julian, and Jose Ignacio Garcia Bielsa. "Study of the Effects on Employment of Public Aid to Renewable Energy Sources." Universidad Rey Juan Carlos, 2009.

Apergis, Nicholas, and James E. Payne. "Renewable Energy Consumption and Economic Growth: Evidence from a Panel of Oecd Countries." *Energy Policy* 38 (2010).

Bing, Shaoxian, Zhixue Li, Xingke Wang, Wei Lu, and Xiaojun Zhao. "Comparative Analysis of the Oil Production Cost Structure in China and Abroad." *Journal of China University of Petroleum* 24, no. 5 (2008).

Bowen, Alex. "'Green' Growth, 'Green' Jobs and Labor Markets." Center for Climate Change Economics and Policy;

Grantham Research Institute on Climate Change and the Environment, 2012.

CASS, China Academy of Social Sciences. "Study on Low Carbon Development and Green Employment in China." 2010.

Chang, Shiyan, Zhao Lili, Govinda R. Timilsina, and Zhang Xiliang. "Development of Biofuels in China: Technologies, Economics and Politics." In *World Bank Policy Research Working Paper* 6243, 2012.

China Water Risk. "China's Water Crisis Part I." 2010.

Cui, Shujie, Wenjie Zhang, and Li Li. "Research on the Cost Compositions and Cost Management of Chinese Oil Supply Chain." *China Flow Economy, Zhongguo Liutong Jingji*, no. 2 (2010).

FAO, Food and Agriculture Organization of the United Nations. "The State of Food and Agriculture in Asia and the Pacific Region 2008." Bangkok, 2008.

———. "Biofuels and Food Security." In *A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome, 2013.

Finance, Bloomberg New Energy. "Moving Towards a Next-Generation Ethanol Economy." 2012.

———. "Global Trends in Renewable Energy Investment 2014." Frankfurt School- UNEP Collaborating Center for Climate & Sustainable Energy Finance, 2014.

Fronzel, Manuel, Nolan Ritter, Christoph M. Schmidt, and Colin Vance. "Economic Impacts from the Promotion of Renewable Energy Technologies: The German Experience." In *Ruhr economic papers*, 2009.

Gang, Fan, Nicholas Stern, Ottmar Edenhofer, Xu Shanda, Eklas Eklund, Frank Ackerman, Li Lailai, and Karl Haldrup. *The Economics of Climate Change in China- Towards a Low-Carbon Economy*. Edited by Tom Gill London and Washington: Earthscan, 2011.

Greenpeace. "Global Wind Energy Outlook 2012." 2012.

———. "Dangerous Breathing-- Pm2.5: Measuring the Human Health and Economic Impacts on China's Largest Cities." 2012.

———. "The End of China's Coal Boom." 2014.

Huang, Phillip CC. "China's Neglected Informal Economy Reality and Theory." *Modern China* 35, no. 4 (2009): 405-38.

IPCC. "Climate Change 2014: Mitigation of Climate Change." Cambridge, UK and New York, NY, USA: Cambridge University Press, 2014.

IRENA, International Renewable Energy Agency. "Renewable Energy Jobs: Status, Prospects and Policies." 2011.

———. "Renewable Energy Technologies: Cost Analysis Series- Solar Photovoltaics." In *Renewable Energy Technologies: Cost Analysis Series*, 2012a.

———. "Renewable Energy Technologies: Cost Analysis Series--Wind Power." In *Renewable Energy Technologies: Cost Analysis Series*, 2012b.

———. "Renewable Power Generation Costs in 2012: An Overview ", 2013.

Jutting, Johannes, Jante Parlevliet, and Theodora Xenogiani. "Informal Employment Re-Loaded." In *OECD Working Paper No.266*. <http://www.oecd.org/dev/39900874.pdf>, 2008.

Lehr, Ulrike, Joachim Nitsch, Marlene Kratzat, Christian Lutz, and Dietmar Edler. "Renewable Energy and Employment in Germany." *Energy Policy* 36, no. 1 (2008): 108-17.

Li, Junfeng, Sicheng Wang, Minji Zhang, and Lingjuan Ma. "China Solar Pv Report." China Environmental Science Press, 2007.

Liu, Jianguo, and Jared Diamond. "China's Environment in a Globalizing World." *Nature* 435, no. 30 (30 June 2005): 1179-86.

Matus, Kira, Kyung-Min Nam, Noelle E. Selin, Lok N. Lamsal, John M. Reilly, and Sergey Paltsev. "Health Damages from Air Pollution in China." *Global Environment Change*, no. 22 (2012): 55-65.

McKinsey & Company. "From Bread Basket to Dust Bowl." 2009.

Mitchell, Timothy. *Carbon Democracy: Political Power in the Age of Oil*. UK and US: Verso, 2011.

Moreno, Blanca, and Ana Jesus Lopez. "The Effects of Renewable Energy on Employment: The Case of Asturias (Spain)." *Renewable and Sustainable Energy Reviews* 12, no. 3 (2008): 732-51.

National Development and Reform Commission, NDRC. "2050 Roadmap for Wind Energy Development in China." 2012.

NDRC, Energy Research Institute at. "China's Wind Energy Development Roadmap 2050." 2011.

Pollin, Robert, Heidi Garret-Peltier, James Heintz, and Bracken Hendricks. "Green Growth: A U.S. Program for Controlling Climate Change and Expanding Job Opportunities." Center for American Progress, 2014b.

Pollin, Robert, Heidi Garrett-Peltier, James Heintz, and Shouvik Chakraborty. "Global Green Growth: Clean Energy Industrial Investments and Expanding Job Opportunities." Political Economy Research Institute (PERI), United Nations Industrial Development Organization (UNIDO) and Global Green Growth Institute (GGGI), 2014a.

Pollin, Robert, James Heintz, and Heidi Garrett-Peltier. "The Economic Benefits of Investing in Clean Energy: How the Economic Stimulus Program and New Legislation Can Boost U.S. Economic Growth and Employment." 2009.

Ragwitz, Mario, Wolfgang Schade, Barbara Breitschopf, Rainer Walz, Nicki Helfrich, and Fraunhofer ISI. "Employment-- the Impact of Renewable Energy Policy on Economic Growth and Employment in the European Union." 2009.

Raswant, Vineet, Nancy Hart, and Monica Romano. "Biofuel Expansion: Challenges, Risks and Opportunities for Rural Poor People." In Round Table organized during the Thirty-first session of IFAD's Governing Council, 2008.

REN21, Renewable Energy Policy Network for the 21st Century. "Renewables 2012 Global Status Report." 2012.

———. "Renewables 2013 Global Status Report." 2013.

Rose, Adam Z., and Dan Wei. "The Economic Impacts of Coal Utilization and Displacement in the Continental United States, 2015." PA: The Pennsylvania State University, 2006.

Strietska-Ilina, Olga, Christine Hofmann, Mercedes Duran Haro, and Shinyoung Jeon. "Skills for Green Jobs: A Global View." Geneva: International Labor Office, 2011.

UNEP, ILO, IOE, and ITUS. "Green Jobs-- Towards Decent Work in a Sustainable, Low-Carbon World." 2008.

USDA, Foreign Agricultural Service. "People's Republic of China: Biofuels Annual." 2013.

Wei, Max, Shana Patadia, and Daniel M. Kammen. "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the U.S?." *Energy Policy* 38 (2010): 919-31.

Xie, Ying, Zhongfu Tan, Jing Cheng, Qinghui Hu, and Shuxiang Wang. "Generation Cost Analysis of Coal-Fired Power Plant in Environment of Energy Saving and Emission Reduction Dispatching." *Power System Technology* 35, no. 2 (2011).

Yang, Congmin, and Liyuan Yang. "Studies on the Scale of Rural Migrant Workers in Contemporary China (Dangdai Zhongguo Nongmingong Liudong Guimo Kaocha)." China Academy of Social Sciences, 2010.

Yishui, Tian, Zhao Lixin, Meng Haibo, Yao Zonglu, and Sun Liying. "Evaluating the Technologies and Economic Feasibility of Biomass Energy in Rural China, Zhongguo Nongcun Shengwuzhineng Liyong Jishu He Jingji Pingjia." *Transactions of the CSAE, Nongye gongcheng xuebao* 27, no. 1 (May 2011 2011): 1.

Yushi, Mao, Sheng Hong, and Yang Fuqiang. "The True Cost of Coal." Beijing, 2008.

Zhang, Libin. "Development of Green Employment in China, Zhongguo Lvse Jiuyede Fazhan." *China Employment*, no. 12 (2010): 6.

Table 3.1. Employment estimates of investing renewable energy in the existing literature (continued onto next page)

Studies	Methodology	Specify sectors	Specify formal or informal employment	Specify direct or indirect jobs	Specify job creation relative to spending level	Stock or flow	Total employment generation for renewable energy investment (million)
UNEP et.al (2008)	Interview officials and experts	Wind, solar and biomass	No	No	No	Stock; “by 2007”	0.9
CREIA (2009)	NA	NA	No	No	No	Flow; 2008	1.1
CASS (2010)	2005 I-O table of three aggregated levels	Wind and solar	No	Yes	580 billion RMB	Stock; 2008-2011	30
China’s 12th Five Year Plan (2011)	NA	Bioenergy	No	No	1.8 trillion RMB	Stock; 2011-2015	3.6
CCICED (2011)	NA	NA	No	No	\$909 billion	Stock; 2011-2015	10.6
IRENA (2011)	Literature survey	Wind, solar thermal and solar PV ¹⁶⁶	No	No	No	Stock; “by 2010”	0.3

¹⁶⁶ Solar thermal technology first translates the sun’s light to heat and then to electricity, while solar PV directly converts the sun’s light to electricity. Therefore solar PV technology is only effective during daylight hours as storing electricity is not a particularly efficient process as compared to heat storage.

	Assuming 14 person/years of employment for every new megawatt and €23 billion of annual investment	Wind	No	No	Annual average of €23 billion	Stock; by 2020	0.3
Greenpeace (2012)							
NDRC (2012)	NA	Wind	No	No	1.8 trillion RMB	Stock; by 2050	0.7
REN21 (2013)	Literature survey	Wind, solar and biomass	No	Yes	No	Stock; 2009-2012	1.7

Source: Author's compilation.

Table 3.2. Annual average wage (RMB) comparison between urban unit employees and rural migrant workers

	Urban unit employees	Rural migrant workers	Rural wages as a share of the Urban Wages
2008	28,898	16,080	56%
2009	32,244	17,004	53%
2010	36,539	20,280	56%
2011	41,799	24,588	59%
2012	46,769	27,480	59%

Source: Table 4-11 China Statistical Yearbook 2013 and National report on rural migrant workers in 2013.

Table 3.3. Urban employment and urban units employment in 2007 and 2012 (in millions)

Category	2007	%	2012	%
Urban employment (million)	293.5	100	371.0	100
Urban units employment	120.2	41.0	152.4	41.1
State-owned Units	64.2	21.9	68.4	18.4
Collective-owned Units	7.2	2.5	5.9	1.6
Other Ownership Units	48.8	16.6	78.1	21.1
Urban informal employment	173.3	59.0	218.6	58.9
Urban private enterprises	45.8	15.6	75.6	20.4
Self-employment	33.1	11.3	56.4	15.2
Not formally counted	94.4	32.2	86.6	23.3

Source: China Labor Statistical Yearbook 2008 and 2012, Table 1-1. Details of urban private enterprises and self-employed are retrieved from Table 4-14 and Table 4-15 in China Statistical Yearbook (2008); Table 4-8 and Table 4-9 in China Statistical Yearbook (2013).

Table 3.4. In-grid solar PV electricity investment costs in 2006

Item	Percentage (%)
Research	2
Industrial design	2
Solar PV battery (including the panels)	66
Silicon	45.2
Battery	10.0
Electronic components	10.8
GCI (grid connector inverter)	10
Electricity distribution measuring and cables	10
Transportation	1.6
Installation and testing	3.6
Grid connection testing	1.6
Tax and other expenses	3.2

Source: Li et.al (2007)

Table 3.5. Cost components of Solar PV of roof-top and ground-mounted types

	Utility Scale				Residential Scale	
	In-grid		Off-grid			
Module cost	80%		30%		50%	
Silicon materials	40		15		25	
Cell processing/ manufacturing	20		7.5		12.5	
Module assembling	20		7.5		12.5	
BOS cost	20%		70%		50%	
	Roof- top	Ground-mounted	Roof- top	Ground-mounted	Roof- top	Ground-mounted
Inverter	2	3	8	9	5	6
Mounting and racking components	6	6	21	22	15	16
Combiner box and miscellaneous electrical components	1	2	5	5	3	4
Site preparation and installation, labor costs	5	3	18	12	13	9
Battery storage	1	1	4	4	3	3
System design, management, etc	4	5	15	18	11	13

Source: Calculated by author based on IRENA (2012) Figure 4.2 and 4.5.

Table 3.6. Cost Structure for the Chinese Solar PV industry in 2012

Category	USD/Watt
PV module costs	0.75
BOS costs except installation costs for utility-scale system (ground-mounted)	0.95
Total installed costs for ground-mounted system	2.2

Source: Compiled by author based on IRENA (2013), p52-5

Table 3.7. Detailed cost structure for the Chinese Solar PV industry in 2012

	USD per Watt	Percentage in 2012	Percentage in 2007
PV module costs	0.75	34.1	45.2
Silicon materials		17	
Cell processing/ manufacturing		8.5	
Module assembling		8.5	
BOS costs except installation costs	0.95	43.2	49.6
Inverter		7.6	10
Mounting and racking components		15.2	11.6
Combiner box and miscellaneous electrical components		5.1	10.8
Battery storage		2.5	10
System design, management, etc		12.7	7.2
Installation costs	0.5	22.7	5.2
Site preparation and installation, labor costs		22.7	

Source: Calculated by author based on Table 3 to Table 5

Table 3.8. Industries and Weights for Solar Energy in the I-O Models

I-O Industry	Weight (%)
Mining of Non-Ferrous Metal Ores	17.1
Smelting of Non-Ferrous Metals and Manufacture of Alloys	8.5
Manufacture of Equipments for Power Transmission and Distribution and Control	11.1
Manufacture of Other Electronic Equipment	12.7
Manufacture of Special Purpose Machinery for Mining, Metallurgy and Construction	15.2
Research and Experimental Development	12.7
Construction	22.7

Source: calculation by author based on Table 6

**Table 3.9. On-shore wind energy cost structure: the world average versus China
(continued onto next page)**

World		Cost in	Weights
average cost		China	(%)
structure		(US\$/kW)	
	Rotor blades (glass fibre, epoxy resin or polyester)	50%~60% of the turbine costs, or 32% to 50% of the total costs	28
	Tower		
	Gearbox		
		13% of the turbine costs, therefore 8.3% to 11% of the total costs	7
	Generator, transformer, power converter		
Turbine cost (64% to 84%)		610	
	Other costs (miscellaneous costs associated with tower, such as rotor hub, cabling and rotor shafts)		12
	Construction of access roads and other related infrastructure required for the wind farm		
Civil works (4% to 16%)		260	22

Transportation and installation of wind turbine and towers		
<hr/>		
Grid connection costs (9% to 14%)	Connection to the local distribution or transmission network	
		<i>260 18</i>
<hr/>		
Planning and project costs (4% to 10%)		
		<i>169 13</i>
<hr/>		
Total		1300
<hr/>		

Source: Author's own calculation based on IRENA 2012b, p19&p24; IRENA (2013).
Note: Italicized numbers are calculated by author assuming world average cost share.

Table 3.10. Industries and Weights for Wind Energy in the I-O Models

I-O Industry	Weight (%)
Research and Experimental Development	13
Construction	22
Manufacture of Synthetic Materials	10
Manufacture of Boiler and Prime Mover	7
Manufacture of Metal Products	30
Manufacture of Equipments for Power	10
Transmission and Distribution and Control	
Production and Supply of Electric Power and	8
Heat Power	

Source: calculation by author based on Table 8

Table 3.11. Bioenergy cost structure

	Weight (%)
Grow and transport biomass feedstock	45
Prime mover and fuel and conversion system	31.5
Fuel handling and preparation machinery	4.5
Infrastructure& logistics	7.7
Civil works	7.3
Grid connection	3
Planning	1

Source: Author's own calculation based on IRENA 2013

Table 3.12. Industries and Weights for Bioenergy in the I-O Models

I-O Industry	Weight (%)
Agriculture	25
Forestry	20
Manufacture of Lifters	36
Construction	15
Manufacture of Equipment for Power	3
Transmission and Distribution and Control	
Research and Experimental Development	1

Source: calculation by author based on Table 10

Table 3.13. Industries and Weights for Coal in the I-O Models

I-O Industry	Weight (%)
Mining and Washing of Coal	18
Coking	18
Manufacture of Special Purpose Machinery for Mining, Metallurgy and Construction	1
Production and Supply of Electric Power and Heat Power	10
Transport Via Railway	51
Other Services	2

Source: calculation by author based on Mao et.al (2008) and Xie et.al (2011)

Table 3.14. Cost structure of Oil/Natural Gas energy

	Case study 1	Case study 2	Average	
Material Cost	26.5	12.5	19.5	
Wage and Compensation	4.2	4.7	4.45	
Mining Cost (well-injecting fee, labor under-well fee, well testing fee, maintenance and repair costs, etc)	25.8	54.8	40.3	Mining
Transportation fee	7.9	4.8	6.35	Transportation
Management	35.6	23.2	29.4	R&D

Source: Bing et.al (2008)

Note: Case study 1 is based on data from China National Petroleum Corporation (CNPC);
Case study 2 is based on data from China Petroleum and Chemical Cooperation (or SINOPEC)

Table 3.15. Industries and weights for oil/gas energy in the I-O Models

I-O Industry	Weight (%)
Extraction of Petroleum and Natural Gas	50
Processing of Petroleum and Nuclear Fuel	20
Transport Via Pipeline	5
Other Services	25

Source: calculation by author based on Table 14

Table 3.16. Total employment generation in renewable energy and fossil fuel energy sectors (unit: jobs per \$1 Million)

	Direct	Indirect	Direct+ Indirect
Renewables			
(average)	93.1	69.2	162.3
Solar PV	28.1	72.0	100.1
Wind	27.1	73.0	100.1
Bioenergy	224.0	62.5	286.4
Fossil Fuels			
(average)	49.5	47.1	96.7
Coal	68.0	43.6	111.6
Oil/Natural Gas	31.0	50.7	81.7

Source: Author's own calculation

Table 3.17. Formal and informal employment share in total employment in renewable energy and fossil fuel energy sectors

	Total employment (jobs per \$1 Million)	Formal employment share	Informal employment share
Renewables			
Solar PV	100.1	26%	74%
Wind	100.1	25%	75%
Bioenergy	286.4	9%	91%
Fossil Fuels			
Coal	111.6	30%	70%
Oil/Natural Gas	81.7	19%	81%

Source: Author's calculation

Table 3.18. Formal employment generation in renewable energy and fossil fuel energy sectors (unit: jobs per \$1 Million)

	Direct	Indirect	Direct+ Indirect
Renewables			
Solar PV	11.0	14.7	25.7
Wind	9.8	14.9	24.7
Bioenergy	13.2	11.7	24.9
Fossil Fuels			
Coal	23.5	9.5	33.0
Oil/Natural Gas	10.1	5.8	15.9

Source: Author's calculation

Table 3.19. Informal employment generation in renewable energy and fossil fuel energy sectors (unit: jobs per \$1 Million of USD)

	Direct	Indirect	Direct+ Indirect
Renewables			
Solar PV	17.1	57.3	74.4
Wind	17.3	58.1	75.4
Bioenergy	210.8	50.8	261.4
Fossil Fuels			
Coal	44.5	34.1	78.6
Oil/Natural Gas	20.9	44.9	65.8

Source: Author's calculation

Table 3.20. Total Employment generation between 2010 to 2015

		Target investment in 2010-2015 (billion USD)	Total Formal Employment generation in 2010- 2015 (million jobs)	Formal + Informal Employment generation in 2010- 2015 (million jobs)
Solar	Direct	40.3	0.5	1.1
	Total	25	1.0	4.0
Wind	Direct	85.5	0.8	2.3
	Total	24.7	2.1	8.6
Bioenergy	Direct	22.6	0.3	5.1
	Total	25	0.6	6.5

Source: Author's own calculation based on the investment information from National Development and Reform Commission (2012), 12th Five Year Plan on the renewable energy development p37.

Table 3.21. Cumulative employment generation by 2020, 2030 and 2050 relative to 2010 level

		Cumulative investment target (billion USD)			Formal Sector: cumulative employment generation (millions)			Formal and Informal Sector: cumulative employment generation (millions)		
		2020	2030	2050	2020	2030	2050	2020	2030	2050
Solar	Direct				1.6	3.6	11.2	3.5	7.6	23.9
	Total	124.6	269.5	850.4	3.1	6.7	21.3	12.5	27.0	85.1
Wind	Direct				2.6	5.6	17.7	3.4	15.5	48.9
	Total	264.4	571.8	1804.1	6.5	14.1	44.6	12.5	57.2	180.6
Bioenergy	Direct				0.9	2.0	6.3	27.9	33.9	106.8
	Total	69.9	151.1	476.9	1.7	3.8	11.9	35.7	43.3	136.6

Source: Author's calculation based on the investment target in National Development and Reform Commission (2012), China's wind energy development roadmap, Table 3-2.
Note: Investment target for wind is direct in National Development and Reform Commission (2012). Investment target for bioenergy and solar is derived based on the assumption that they share the same growth rate with that for the wind energy sector.

Table 3.22. Output multipliers and percentage changes in energy sectors in China, 1995-2011

	1995	2007	2011	1995 to 2007	2007 to 2011
Renewables			Annual average % increase		
Solar	2.41	2.56	2.64	0.5%	0.7%
Wind	2.40	2.56	2.58	0.6%	0.2%
Bioenergy	2.17	2.31	2.41	0.5%	1.1%
Fossil fuels					
Coal	2.05	2.15	2.14	0.4%	-0.1%
Oil and Natural Gas	2.18	2.17	2.06	-0.1%	-1.3%

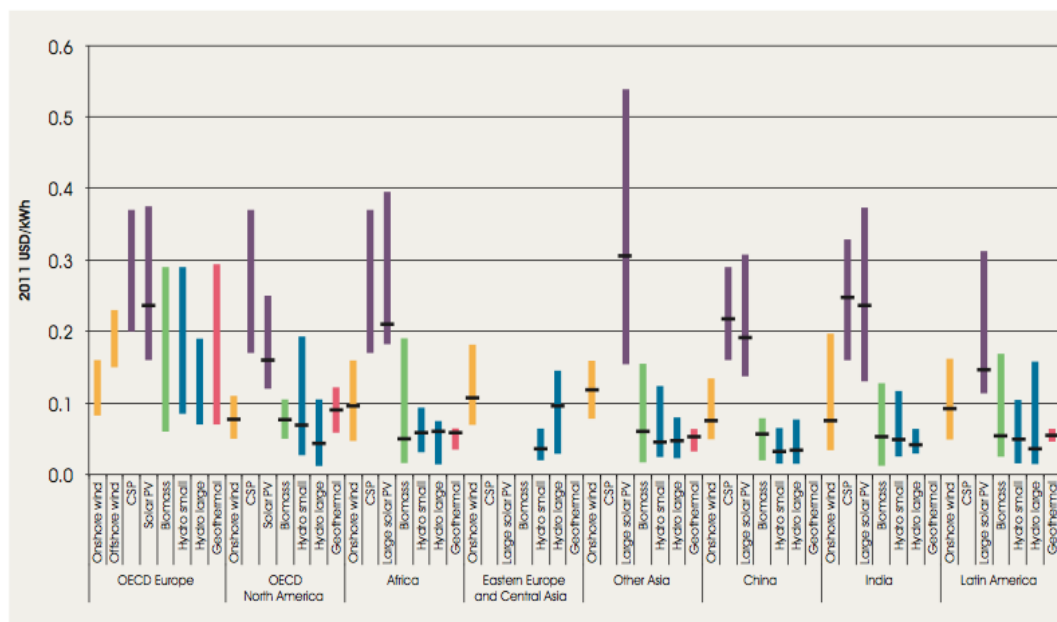
Source: Author's calculation based on World Input-Output Database

Table 3.23. Productivity changes in energy sectors in China*Measured as the inverse of productivity: Number of persons 1 million of RMB*

	2007	2011	2007 to 2011
Renewables			Annual Average
			Percentage change
Solar	3.19	2.03	-9.1%
Wind	3.19	2.02	-9.2%
Bioenergy	3.23	2.14	-8.4%
Fossil fuels			
Coal	2.67	1.22	-13.6%
Oil and Natural Gas	0.91	0.78	-3.6%

Source: Author's calculation based on Table 13-2 or 14-2 Main Indicators of Industrial Enterprises above Designated Size by Industrial Sector from China Statistical Yearbook 2008-2012. Price index based on Table 9-1, China Statistical Yearbook 2012. Data for productivity for construction sector is calculated based on Table 15-34 CSY 2012 and Table 14-36 in CSY 2008.

Figure 3.1. Typical cost components for renewable power generation technologies by region¹⁶⁷



Source: Extracted from IRENA (2013) Figure 2.3

¹⁶⁷ Solar photovoltaic (PV) directly converts solar energy into electricity using a PV cell made of a semiconductor material. Concentrating solar power (CSP) devices concentrate energy from the sun's rays to heat a receiver to high temperatures. This heat is transformed first into mechanical energy (by turbines or other engines) and then into electricity – solar thermal electricity (STE). See definition from IEA, at <http://www.iea.org/topics/solarpvandcsp/>. Other renewable energy sources in the figure are self-explanatory.

BIBLIOGRAPHY

- Abbink, K., et al. (2006). "Group size and social ties in microfinance institutions." *Economic Inquiry* 44(4): 614-628.
- Adams, D. W. and J. D. V. Pischke (1992). "Microenterprise credit programs: Deja vu." *World Development* 20(10): 1463-1470.
- Aghion, B. A. r. d. and J. Morduch (2000). "Microfinance beyond group lending." *Economics of Transition* 8(2): 401-420.
- Alexander, P. and A. Chan (2004). "Does China Have an Apartheid Pass System?" *Journal of Ethnic and Migration Studies* 30(4): 609-629.
- Alvarez, G. C., et al. (2009). Study of the effects on employment of public aid to renewable energy sources, Universidad Rey Juan Carlos.
- Andreas, J. and S. Zhan (2015). "Hukou and land: market reform and rural displacement in China." *The Journal of Peasant Studies*.
- Apergis, N. and J. E. Payne (2010). "Renewable energy consumption and economic growth: Evidence from a panel of OECD countries." *Energy Policy* 38.
- Arrow, K. (1965). "Criteria for Social Investment." *Water Resources Research* 1(1): 1-8.
- Arrow, K. (1966). *Discounting and Public Investment Criteria*. Baltimore.
- Bank, W. (2002). *Empowerment and Poverty Reduction: A Sourcebook*.
- Bardhan, P., et al. (2012). "State-led or Market-led Green Revolution? Role of Private Irrigation Investment vis-a-vis Local Government Programs in West Bengal's Farm Productivity Growth." *Journal of Development Economics*(99): 222-235.
- Barslund, M. and F. Tarp (2008). "Formal and Informal Rural Credit in Four Provinces of Vietnam." *Journal of Development Studies* 44(4): 485-503.
- Bateman, M. (2010). *Why Doesn't Microfinance Work?-- The Destructive Rise of Local Neoliberalism*. New York, Zed Books Ltd.
- Bateman, M. and H.-J. Chang (2009) *The Microfinance Illusion*.
- Becker, G. S. and C. B. Mulligan (1997). "The endogenous determination of time preference." *The Quarterly Journal of Economics*: 729-758.

- Bello., W. B. (2008). "The Effect of Rain-fed and Supplementary Irrigation on the Yield and Yield Components of Maize in Mekelle, Ethiopia." *Ethiopian Journal of Environmental Studies and Management* 1(2).
- Benzion, U., et al. (1989). "Discount Rates Inferred From Decisions: An Experimental Study." *Management Science*(35): 270-284.
- Besley, T. and S. Coate (1995). "Group lending, repayment incentives and social collateral." *Journal of Development Economics* 46(1): 1-18.
- Bing, S., et al. (2008). "Comparative analysis of the oil production cost structure in China and abroad." *Journal of China University of Petroleum* 24(5).
- Binswanger, H. P. (2006). Empowering Rural People for Their Own Development. Elmhirst Lecture at International Association of Agricultural Economists Conference. Gold Coast, Australia.
- Binswanger, H. P., et al. (1993). "How infrastructure and financial institutions affect agricultural output and investment in India." *Journal of Development Economics* 41(2): 337-366.
- Binswanger, H. P. and M. R. Rozenzweig (1986). "Behavioral and Material Determinants of Production Relations in Agriculture." *Journal of Development Studies*(22): 503-539.
- Bowen, A. (2012). "Green" growth, "green" jobs and labor markets, Center for Climate Change Economics and Policy; Grantham Research Institute on Climate Change and the Environment.
- Brandt, L., et al. (2004). Are China's Financial Reforms Leaving the Poor Behind. *Financial Sector Reform in China*. USA: 204-230.
- Brown, J. (2012). *City versus countryside in Mao's China*. USA, Cambridge University Press.
- Bureau, P. s. B. o. C. a. C. S. (2009). *Survey Report on Rural Credit People's Bank, China*.
- Carter, M. R. and P. Olinto (2003). "Getting Institutions "Right" for Whom? Credit Constraints and the Impact of Property Rights on the Quantity and Composition of Investment." *American Journal of Agricultural Economics* 85(1): 173-186.
- CASS, C. A. o. S. S. (2010). *Study on low carbon development and green employment in China*.
- Chan, K. W. (1988). "Rural-urban migration in China, 1950-1982: estimates and analysis." *Urban Geography* 9(1): 53-84.

- Chan, K. W. (1992). "Economic growth strategy and urbanization policies in China, 1949-1982." *International Journal of Urban and Regional Research* 16(2): 275-305.
- Chan, K. W. (1994). *Cities With Invisible Walls: Reinterpreting Urbanization in Post-1949 China*. Hong Kong, Oxford University Press.
- Chan, K. W. (1996). "Post-Mao China: A Two-Class Urban Society in the Making." *International Journal of Urban and Regional Research* 20(1): 134-150.
- Chan, K. W. (2001). "Recent Migration in China: Patterns, Trends, and Policies." *Asian Perspectives* 25(4): 127-155.
- Chan, K. W. (2003). *Migration in China in the Reform Era: Characteristics, Consequences, and Implications. The Chinese Development Miracle: Origins, Transformation, and Challenges*. A. So. Armonk, M.E. Sharpe: 111-135.
- Chan, K. W. (2004). "Chinese Hukou reforms and rural-urban migration." *China Labor Economics* 1: 108-123.
- Chan, K. W. (2009). "The Chinese Hukou System at 50." *Eurasian Geography and Economics* 50(2): 197-221.
- Chan, K. W. (2010). "A China Paradox: Migrant Labor Shortage amidst Rural Labor Supply Abundance." *Eurasian Geography and Economics* 51(4): 513-530.
- Chan, K. W. (2010). "The Global Financial Crisis and Migrant Workers in China: There is No Future as a Labourer; Returning to the Village has No Meaning." *International Journal of Urban and Regional Research* 34(3): 659-677.
- Chan, K. W. (2010). "The Chinese Household Registration System and Migrant Labor in China: Notes on a Debate." *Population and Development Review* 36(2): 357-364.
- Chan, K. W. and W. Buckingham (2008). "Is China abolishing the Hukou System." *The China Quarterly* 195: 582-606.
- Chan, K. W. and F. Cai (2000). *The Political Economy of Urban Protectionist Employment Policies in China*. Working Paper Series, Chinese Academy of Social Sciences Institute of Population Studies.
- Chan, K. W., et al. (1999). "Hukou and Non-hukou Migrations: Comparisons and Contrasts." *International Journal of Population Geography* 5(6): 425-448.
- Chan, K. W. and X. Xu (1985). "Urban Population Growth and Urbanization in China since 1949: Reconstructing a Baseline." *The China Quarterly*(104): 583-613.

- Chan, K. W. and L. Zhang (1999). "The Hukou System and Rural-Urban Migration in China: Processes and Changes." *The China Quarterly*(160): 818-855.
- Chang, S., et al. (2012). *Development of Biofuels in China: Technologies, Economics and Politics*. World Bank Policy Research Working Paper 6243.
- Cheng, T. (1991). *Dialectics of contro: the household registration (hukou) system in contemporary China*. Dept. of Sociology, State University of New York at Binghamton. Doctoral Thesis.
- Cheng, T. and M. Seldon (1994). "The origins and social consequences of China's hukou system." *The China Quarterly*(139): 644-668.
- China Water Risk (2010). *China's Water Crisis Part I*.
- Christiansen, F. (1990). "Social division and peasant mobility in mainland China: the implications of hukou system." *Issues and Studies* 26(4): 78-91.
- Coleman, B. E. (1999). "The impact of group lending in Northeast Thailand." *Journal of Development Economics* 60: 105-141.
- Coleman, B. E. (2000). *Risk, mutual assistance, and mutual insurance among village bank members*. Manila, Asian Development.
- Cui, S., et al. (2010). "Research on the cost compositions and cost management of Chinese oil supply chain." *China Flow Economy, Zhongguo Liutong Jingji*(2).
- Dinar, A. and A. Keck (1997). "Private irrigation investment in Colombia: effects of violence, macroeconomic policy, and environmental conditions." *Agricultural Economics*(16): 1-15.
- Du, X. (2002). "Conceptual framework of rural finance, Reform of rural finance and Micro-finance." *Chinese Rural Economy (Zhongguo Nongcun Jingji)*(8): 4-9.
- Dutton, M. R. (1992). *Policies and Punishment in China*. Cambridge, Cambridge University Press.
- Fan, C. C. (2008). *China on the Move: Migration, the State, and the Household*. New York, Routledge.
- Fan, S. and X. Zhang (2002). "Production and Productivity Growth in Chinese Agriculture: New National and Regional Measures." *Economic Development and Cultural Change* 50(4).
- FAO, F. a. A. O. o. t. U. N. (2008). *The State of Food and Agriculture in Asia and the Pacific Region 2008*. Bankok.

FAO, F. a. A. O. o. t. U. N. (2013). Biofuels and Food Security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

Feder, G., et al. (1989). "Agricultural Credit and Farm Performance in China." *Journal of Comparative Economics* 13(4): 508-526.

Feder, G., et al. (1990). "The Relationship between Credit and Productivity in Chinese Agriculture: A Microeconomic Model of Disequilibrium." *American Journal of Agricultural Economics* 72(5): 1151-1157.

Feder, G., et al. (1991). *The Nascent Credit Market in Rural China*, Center for Research in Economic Growth, Standard University.

Feder, G., et al. (1992). "The Determinants of Farm Investment and Residential Construction in Post-Reform China." *Economic Development and Cultural Change* 41(1): 1-26.

Fields, G. S. (2004). *Dualism in the labor market: A perspective on the Lewis model after half a century*, Cornell University.

Finance, B. N. E. (2012). *Moving towards a next-generation ethno economy*.

Finance, B. N. E. (2014). *Global trends in renewable energy investment 2014*, Frankfurt School- UNEP Collaborating Center for Climate& Sustainable Energy Finance.

Foltz, J. D. (2004). "Credit Market Access and Profitability in Tunisian Agriculture." *Agricultural Economics*(30): 229-240.

Fronzel, M., et al. (2009). *Economic impacts from the promotion of renewable energy technologies: the German experience*. Ruhr economic papers.

Gang, F., et al. (2011). *The Economics of Climate Change in China- Towards a Low-Carbon Economy*. London and Washington, Earthscan.

Gao, Z. (1998). "The development of water management in irrigation, Guangai shui guanli de fazhan qushi." *China Rural Irrigation and Hidroelectriciy, Zhongguo nongcun shuili shuidian*(12).

Garnaut, R., et al. (2001). *Private Enterprise in China*, Asia Pacific Press.

Gine, X. (2011). "Access to Capital in Rural Thailand: An Estiamted Model of Formal vs. Informal Credit." *Journal of Development Economics* 96(1): 16-29.

Gine, X., et al. (2006). Microfinance games. Yale University Economic Growth Center Discussion Paper.

Goldstein, M. and C. Udry (2005). The Profits of Power: Land Rights and Agricultural Investment in Ghana. Economic Growth Center discussion paper. Yale University and Leibniz Information Center for Economics.

Green, L., et al. (1994). "Discounting of Delayed Rewards: A Life-Span Comparison." *Psychological Sciences* 5(1): 33-36.

Greenpeace (2012). Global Wind Energy Outlook 2012.

Greenpeace (2012). Dangerous Breathing-- PM2.5: Measuring the Human Health and Economic Impacts on China's Largest Cities.

Greenpeace (2014). The end of China's Coal Boom.

Hayami, Y. and M. Kikuchi (1978). "Investment Inducements to Public Infrastructure: Irrigation in the Philippines." *The Review of Economics and Statistics* 60(1): 70-77.

He, G. and L. Li (2011). "Micro-finance in the large-scale commercial bank." *Chinese Rural Economy (Zhongguo Nongcun Jingji)*(5): 21-26.

Hermes, N. and R. Lensink (2007). "The Empirics of Microfinance: What do we Know?" *The Economic Journal*(117): F1-F10.

Hirshleifer, J. (1961). "Risk, The Discount Rate, and Investment Decisions." *The American Economic Review* 51(2): 112-120.

Hoff, K., et al. (1993). *The Economics of Rural Organization: Theory, Practice, and Policy*. New York, N.Y., Oxford University Press for the World Bank.

Huang, M., et al. (2003). "Effect of Increased Fertilizer Applications to Wheate Crop on Soil-water Depletion in the Loess Plateau China." *Agricultural Water Management* 58(3).

Huang, P. C. (2009). "China's Neglected Informal Economy Reality and Theory." *Modern China* 35(4): 405-438.

Huang, P. C. C., et al. (2012). "Capitalization without Proletarianization in China's Agricultural Development." *Modern China* 38(2): 139-173.

Huang, Q., et al. (2006). "Irrigation, agricultural performance and poverty reduction in China." *Food Policy*(31): 30-52.

Huang, Y. (2001, June 26th, 201). "Hukou system cannot be repealed at this moment." Retrieved April 16th, 2013.

- Hulme, D. (2000). "Is Microdebt Good for Poor People? A Note on the Dark Side of Microfinance." *Small Enterprise Development* 11(1).
- Huppi, M. and G. Feder (1990). "The role of groups and credit cooperatives in rural lending." *The World Bank Research Observer* 5(2): 187-204.
- IPCC (2014). *Climate Change 2014: Mitigation of Climate Change*. Cambridge, UK and New York, NY, USA, Cambridge University Press.
- IRENA, I. R. E. A. (2011). *Renewable energy jobs: status, prospects and policies*.
- IRENA, I. R. E. A. (2012a). *Renewable Energy Technologies: Cost Analysis Series-Solar Photovoltaics*. Renewable Energy Technologies: Cost Analysis Series.
- IRENA, I. R. E. A. (2012b). *Renewable Energy Technologies: Cost Analysis Series--Wind Power*. Renewable Energy Technologies: Cost Analysis Series.
- IRENA, I. R. E. A. (2013). *Renewable Power Generation Costs in 2012: An Overview*
- Jensen, M. C. and M. J. Bailey (1972). *Risk and the Discount Rate for Public Investment. Studies in the Theory of Capital Markets*, Harvard Business School.
- Jiang, L. (2006). "Living Conditions of the Floating Population in Urban China." *Housing Studies* 21(5): 719-744.
- Jutting, J., et al. (2008). *Informal Employment Re-loaded*. OECD Working Paper No.266. <http://www.oecd.org/dev/39900874.pdf>.
- Ka, C.-M. and M. Seldon (1986). "Original Accumulation, Equity and Late Industrialization: The Cases of Socialist China and Capitalist Taiwan." *World Development* 14(10/11): 1293-1310.
- Karlan, D. S. (2007). "SOCIAL CONNECTIONS AND GROUP BANKING." *The Economic Journal*(117).
- Karlan, D. S. and X. Gine (2007). "Group versus individual liability: A field experiment in the Philippines." *Center for Global Development Working Paper*(111).
- Khoi, P. D., et al. (2013). "Formal and informal rural credit in the Mekong River Delta of Vietnam: Interaction and accessibility." *Journal of Asian Economics* 26.
- Kirby, K. N. and R. J. Herrnstein (1995). "Preference Reversals due to Myopic Discounting of Delayed Reward." *Psychological Sciences* 6(2): 83-89.

Knight, J. and L. Song (1999). *The Rural–Urban Divide: Economic Disparities and Interactions in China*. New York, NY, Oxford University Press.

Kohansal, M. R., et al. (2008). "Effect of Credit Accessibility of Farmers on Agricultural Investment and Investigation of Policy Options in Khorasan-Razavi Province." *Journal of Applied Sciences* 8(23): 4455-4459.

Kotz, D. M. and A. Zhu (2011). "The Dependence of China's Economic Growth on Exports and Investment." *Review of Radical Political Economics* 43(1): 9-32.

Lehner, M. (2009). *Group Lending versus Individual Lending in Microfinance*. University of Munich, Governance and the Efficiency of Economic Systems.

Lehr, U., et al. (2008). "Renewable energy and employment in Germany." *Energy Policy* 36(1): 108-117.

Li, J., et al. (2007). *China Solar PV Report*. China Environmental Science Press.

LI, S., et al. (2013). "HOW IMPORTANT ARE ENDOGENOUS PEER EFFECTS IN GROUP LENDING? ESTIMATING A STATIC GAME OF INCOMPLETE INFORMATION." *JOURNAL OF APPLIED ECONOMETRICS*(28): 864-882.

Li, T. (2012, June 27th, 2012). "Hukou system cannot be repealed." Retrieved April, 2013.

Lin, Y., et al. (1994). *Zhongguo de qiji: fazhan zhanlue he jingji gaige* (The China Miracle: Development Strategy and Economic Reform). Shanghai, Shanghai renmin chubanshe (Shanghai People's Publisher).

Liu, J. and J. Diamond (2005). "China's Environment in a Globalizing World." *Nature* 435(30): 1179-1186.

Lv, D. (2010). "Deliberations on China's Rural Irrigation Construction, "Shensi Nongtian Shuili Jianshe de Fangxiang"." *Studies on Irrigation Development*, "Shuili Fazhan Yanjiu"(4).

Mallee, H. (1996). "China's household registration system under reform." *Development and Change* 26: 1-29.

Mallee, H. (1996). "Reform of the hukou system." *Chinese Sociology & Anthropology* 29(1): 3-14.

Matus, K., et al. (2012). "Health damages from air pollution in China." *Global Environment Change*(22): 55-65.

McKinsey & Company (2009). *From Bread Basket to Dust Bowl*.

- Mehmet, O. (1995). "Employment Creation and Green Development Strategy." *Ecological Economics*(15): 11-19.
- Millar, A. and D. Navarick (1984). "Self-control and choice in humans: effects of video game playing as a positive reinforcer." *learning and motivation*(15): 203-218.
- Mitchell, T. (2011). *Carbon democracy: political power in the age of oil*. UK and US, Verso.
- Mohan, R. (2006). "Agricultural Credit in India: Status, Issues and Future Agenda." *Economic and Political Weekly* 41(11): 18-24.
- Moreno, B. and A. J. Lopez (2008). "The effects of renewable energy on employment: the case of Asturias (Spain)." *Renewable and Sustainable Energy Reviews* 12(3): 732-751.
- National Development and Reform Commission, N. (2012). *2050 Roadmap for wind energy development in China*.
- Naughton, B. (2007). *The Chinese Economy*. Cambridge, MA, MIT Press.
- NDRC, E. R. I. a. (2011). *China's wind energy development roadmap 2050*.
- Neuwahl, F., et al. (2008). "Employment impacts of EU biofuels policy: Combining bottom-up technology information and sectoral market simulations in an input–output framework." *Ecological Economics* 68(1-2): 447-460.
- Nolan, P. (1976). "Collectivization in China: Some Comparisons with the USSR." *The Journal of Peasant Studies* 3(2): 192-220.
- Ostrom, E. (2009). *Beyond Markets and States: Polycentric Governance of Complex Economic Systems*. Prize Lecture.
- Park, A., et al. (1997). *Giving Credit Where Credit Is Due: The Changing Role of Rural Financial Institutions in China*. Working Paper No. 71, The William Davidson Institute.
- Park, A. and C. Ren (2001). "Microfinance with Chinese Characteristics." *World Development* 29(1): 39-62.
- Pary, C. E., et al. (2002). "Five years of Bt cotton in China-- the benefits continue." *The Plant Journal* 31(4): 423-430.
- Patnaik, U. (1987). "Three Communes and a Production Brigade: The Contract Responsibility System in China." *Social Scientist* 15(11/12).

Patnaik, U. and S. Natrajan (2000). "Output and Employment in Rural China: Some Post-Reform Problems." *Economic and Political Weekly* 35(38): 16-22.

Pender, J. L. (1996). "Discount Rates and Credit markets: Theory and Evidence from Rural India." *Journal of Development Economics* 50(2): 257-296.

Petrack, M. (2004). "Farm Investment, Credit Rationing, and Governmentally Promoted Credit Access in Poland: A Cross-Sectional Analysis." *Food Policy*(29): 275-294.

Pollin, R., et al. (2014b). *Green Growth: A U.S. Program for Controlling Climate Change and Expanding Job Opportunities*, Center for American Progress.

Pollin, R., et al. (2014a). *Global Green Growth: Clean Energy Industrial Investments and Expanding Job Opportunities*, Political Economy Research Institute (PERI), United Nations Industrial Development Organization (UNIDO) and Global Green Growth Institute (GGGI).

Pollin, R., et al. (2009). *The Economic Benefits of Investing in Clean Energy: How the Economic Stimulus Program and New Legislation Can Boost U.S. Economic Growth and Employment*.

Potter, S. H. (1983). "The Position of Peasants in Modern China's Social Order." *Modern China* 9(4): 465-499.

Qin, H. (2013). "Three kinds of inequality behind the hukou system." Retrieved Jan 30th, 2013.

Ragwitz, M., et al. (2009). *EmployRES-- The impact of renewable energy policy on economic growth and employment in the European Union*.

Raswant, V., et al. (2008). *Biofuel Expansion: Challenges, Risks and Opportunities for Rural Poor People*. Round Table organized during the Thirty-first session of IFAD's Governing Council.

Ratha, D. K. and A. Sarma (1992). "Price Subsidies and Irrigation Investment in India: Macro Implications." *Economic and Political Weekly* 27(39): A117-A121.

Rawski, T. G. (1979). *Economic Growth and Employment in China*. Published for the World Bank, Oxford University Press.

Remenyi, J. (1991). *Where Credit is Due: Income-Generating Programmes for the Poor in Developing Countries*. London, Intermediate Technologies Publications.

REN21, R. E. P. N. f. t. s. C. (2012). *Renewables 2012 Global Status Report*.

- REN21, R. E. P. N. f. t. s. C. (2013). Renewables 2013 Global Status Report.
- Ren, X., et al. (1996). "China's Registration Taboo." *Chinese Sociology & Anthropology* 29(1): 15-26.
- Roe, B. E. and D. R. Just (2009). "Internal and external validity in Economics research: tradeoffs between experiments, field experiments, natural experiments, and field data." *American Journal of Agricultural Economics* 91(5).
- Rose, A. Z. and D. Wei (2006). *The Economic Impacts of Coal Utilization and Displacement in the Continental United States, 2015*. PA, The Pennsylvania State University.
- Samuelson, P. (1964). "Principles of Efficiency: Discussion." *American Economic Review Proceedings* 54(93-96).
- Simas, M. and S. Pacca (2014). "Assesing Employment in Renewable Energy Technologies: A Case Study for WInd Power in Brazil." *Renewable and Sustainable Energy Reviews*(31): 83-90.
- Sinn, M. (2013). "Sequential Group Lending: A Mechanism to Raise the Repayment Rate in Microfinance." *Economica*(80): 326-344.
- Smit, S. and J. K. Musango (2015). "Towards connecting green economy with informal economy in South Africa: A review and way forward." *Ecological Economics* 116(154-159).
- Solinger, D. (1995). *The floating population in the cities: chances for assimilation? Urban Spaces: Autonomy and Community in Contemporary China*. Cambridge, Woodrow Wilson Center Press and Cambridge University Press: 113-139.
- Solinger, D. (1999). *Contesting Citizenship in Urban China*. Berkeley, CA, University of California Press.
- Solinger, D. and K. W. Chan (2002). *The China Difference: City Studies Under Socialism and Beyond*. Understanding the City. J. E. a. C. Mele, Blackwell Press.
- Solnick, J., et al. (1980). "An experiemental analysis of impulsivity and impulse control in humans." *learning and motivation*(11): 61-77.
- Srinivasaro, C., et al. (2014). "Long-term manuring and fertilizer effects on depletion of soil organic carbon stocks under pearl millet-cluster bean-castor rotation in western India." *Land Degradation and Development*(25).

- Stiglitz, J. E. (1990). "Peer monitoring and credit markets." *The World Bank Economic Review* 4(3): 351-366.
- Strietska-Ilina, O., et al. (2011). *Skills for Green Jobs: A Global View*. Geneva, International Labor Office.
- Svedsen, M. and M. W. Rosegrant (1994). "Irrigation development in Southeast Asia beyond 2000: will the future be like the past?" *Water International* 19(1): 25-35.
- Thaler, R. H. (1981). "Some empirical evidence on dynamic inconsistency." *Economics Letters*(8): 201-207.
- Tilman, D. (1998). "The greening of the green revolution." *Nature* 396: 211-212.
- Tsai, K. S. (2004). "Imperfect Substitutes: The Local Political Economy of Informal Finance and Microfinance in Rural China and India." *World Development* 32(9): 1487-1507.
- UNEP, et al. (2008). *Green Jobs-- Towards decent work in a sustainable, low-carbon world*.
- USDA, F. A. S. (2013). *People's Republic of China: Biofuels Annual*.
- Varian, H. R. (1990). "Monitoring Agents with Other Agents." *Journal of Institutional and Theoretical Economics*(146): 153-174.
- Vickrey, W. (1964). "Principles of Efficiency: Discussion." *American Economic Review* LIV: 88-92.
- Wang, F.-L. (2004). "Reformed Migration Control and New Targeted People: China's Hukou System in the 2000s." *The China Quarterly*(177): 115-132.
- Wang, F.-L. (2005). *Organizing through Division and Exclusion: China's Hukou System*. Stanford, CA, Stanford University Press.
- Wang, J., et al. (2009). "The impact of climate change on China's agriculture." *Agricultural Economics* 40: 323-337.
- Wei, M., et al. (2010). "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the U.S?" *Energy Policy* 38: 919-931.
- Wen, T.-J. (2007). "Jianshe Xinnongcun zhongzai silu bentuhua
Localizing is the key to building the new rural society." *Jiansu Rural Economy*(2).

White, L. T. (1977). Deviance, modernization, rations, and household register in urban China. *Deviance and Social Control in Chinese Society*. A. A. Wilson, S. L. Greenblatt and R. W. Wilson. New York, Praeger.

Whyte, M. K. (2010). *One country, two societies: rural-urban inequality in contemporary China*, Harvard University Press.

Wolpin, M. R. R. a. K. I. (1993). "Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India." *Journal of Political Economy* 101(2): 223-244.

Wu, H. X. (1994). "Rural to Urban Migration in the People's Republic of China." *The China Quarterly*(139): 669-698.

Wu, X. (2006). "Communist Cadres and Market Opportunities: Entry into Self-employment in China, 1978-1996." *Social Forces* 85(1).

Wu, X. and D. J. Treiman (2004). "The Household Registration System and Social Stratification in China." *Demography* 41(2): 363-384.

Wydick, B. (1999). "Can social cohesion be harnessed to repair market failures? Evidence from group lending in Guatemala." *Economic Journal*: 463-475.

Xie, Y., et al. (2011). "Generation cost analysis of coal-fired power plant in environment of energy saving and emission reduction dispatching." *Power System Technology* 35(2).

Xu, Z. (2012). "The Chinese Agriculture Miracle Revisited." *Economic and Political Weekly XLVII*(14).

Yang, C. and L. Yang (2010). *Studies on the scale of rural migrant workers in contemporary China (Dangdai Zhongguo Nongmingong Liudong Guimo Kaocha)*. China Academy of Social Sciences.

Yishui, T., et al. (2011). "Evaluating the technologies and economic feasibility of biomass energy in rural China, Zhongguo nongcun shengwuzhineng liyong jishu he jingji pingjia." *Transactions of the CSAE, Nongye gongcheng xuebao* 27(1): 1.

Yu, D.-P. (2002). *Changxiang shehui: cong geli zouxiang kaifang: zhongguo huji zhidu yu hujifa yanjiu*
Urban and rural society: from separation to open-up: studies on the China Household Registration System and Law. Jinan, Shandong People's Publisher.

Yushi, M., et al. (2008). *The True Cost of Coal*. Beijing.

Zhang, L. (2010). "Development of green employment in China, Zhongguo lvse jiuyede fazhan." *China Employment*(12): 6.

Zhang, Q. (1988). "Basic Facts on the Household Registration System." Chinese Economic Studies 22(1).

Zhang, S. (2013). Repeal hukou system and let peasants freely enter the cities. Beijing Morning Newspaper. http://cq.ifeng.com/world/detail-1_2013_04/10/700610_0.shtml.

Zhang, X. (2005). "Spatial Inequality in Education and Health Care in China." China Economic Review(16): 189-204.

Zhou, F. and C. Duan (2006). "Literature Review Regarding the Left-Behind Children." Population Journal(3).